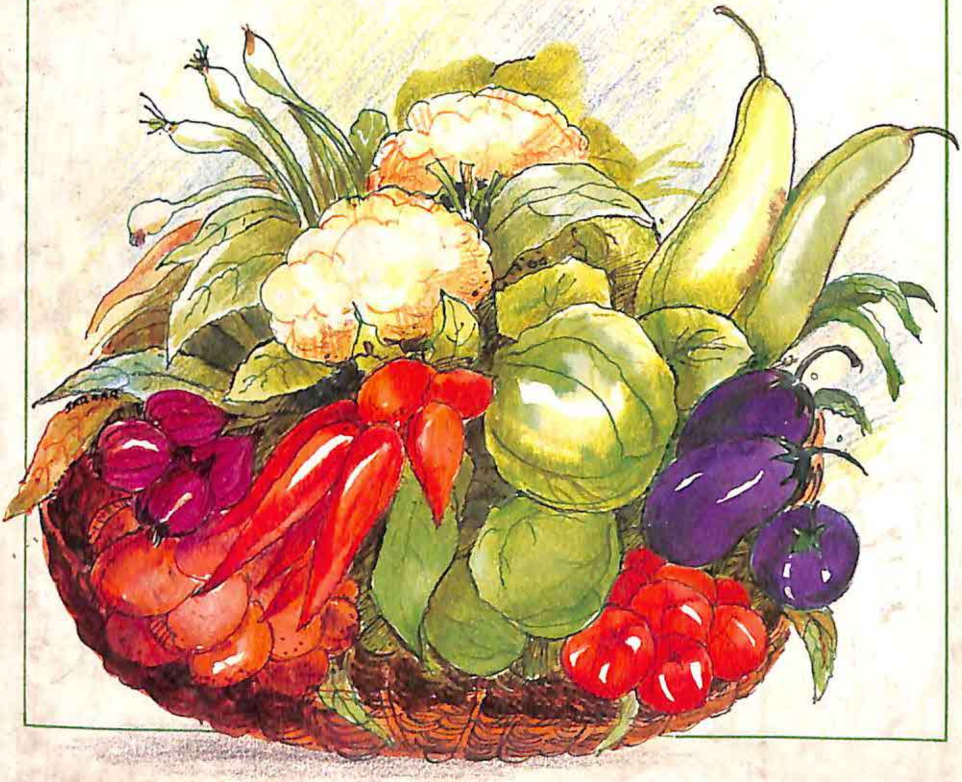
Vegetables

B. CHOUDHURY



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BISHWAJIT CHOUDHURY

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Preface To The First Edition

INTEREST in vegetable growing has increased very rapidly during the last few years. This is because of the greater appreciation of the value of vegetables as food. The lack of a comprehensive book giving details of the cultural operations of the vegetables in a non-or semi-technical language has been felt for long. So when I was approached by the National Book Trust to write such a book, I immediately accepted the offer though not without some hesitation. This was because writing such a book needed some time and to get away from my own research and teaching commitments was not easy. However, I am thankful to the National Book Trust for their patience in giving me sufficient time to complete it.

The main purpose of the book is to acquaint those who are interested in vegetable-growing with the facts and principles of successful production. Care has been exercised to use as little technical language as possible. I have drawn freely upon material from many sources—books, bulletins, scientific papers and unpublished mimeographs. Special mention may be made of the Special Report Series No. 32 of the Indian Council of Medical Research from which the nutritive values of most of the individual vegetables have been mentioned. The other books which were consulted are: *Vegetable Crops* by H.C. Thompson and W.C. Kelly, *Vegetable Growing* by J.E. Knott, *Vegetable Growing* by J.S. Shoemaker, *Vegetable Growing in Northern India* by S.S. Purewal, *Vegetable Crops of India* by K.S. Yawalkar and *Vegetable Growing in Uttar Pradesh* by Y.R. Mehta.

I express my gratitude to my colleagues Shri R. Rajendran, for taking a number of photographs published in the book and to Dr. V.S. Seshadri for valuable assistance in going through the proofs. I am deeply indebted to Dr. B.V. Keskar, Chairman, National Book Trust and Dr. B.P. Pal, Director-General, Indian Council of Agricultural Research, for asking me to write this book.

This book could not have been completed without their continuous encouragement. I also acknowledge the help and encouragement given to me by Dr. M.S. Swaminathan, Director, and Dr. S.K. Mukherjee, Head of the Division of Horticulture, Indian Agricultural Research Institute. Lastly, I shall consider all my efforts well spent if this book, even indirectly, helps in increasing the vegetable production of our country.

BISHWAJIT CHOUDHURY

Preface To The Eighth Edition

THE food production in the country has stabilised for the last few years around 130 to 150 million tonnes. It is estimated that by the turn of this century 225 million tonnes of food will be needed to feed our increasing population. To achieve this herculian task the food production and consumption patterns have to be modified. If we wish to survive as a healthy and well fed nation more area has to be put under quick-maturing, high-yielding and nutritious crops like vegetables. These food crops have to figure more in our farming system and daily diet.

To make the information in this book up-to-date some recent achievements and developments in vegetables have been added. At the same time some earlier recommendations which have become obsolete have been changed or deleted in this edition.

BISHWAJIT CHOUDHURY

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CHAPTER I

Introduction

INDIA STILL depends on Nature for production of food in the major part of the country. The failure of rains in some parts and floods in others create unprecedented food problems. It is very surprising that a country with more than seventy per cent of her population cultivating over 130 million hectares of land has sometimes to depend on other countries for her supply of food. The reason is the low production rate of the land. The success achieved during the last Five Year Plans has been neutralised by the high rate of population growth.

One of the reasons for the high rate of increase in population is the phenomenal progress in medical science. Unfortunately, agricultural science has not been able to keep pace with its medical counterpart. So the only way to solve the problem is to find ways and means to increase food production as fast as possible and also to check the growth rate of population.

One of the main reasons for the low agricultural production in India is the low working capacity of the majority of the population who have been facing mal- and under-nutrition for generations. Correct feeding is essential for a healthy life. Food is broadly classified into cereals, pulses, nuts, oilseeds, vegetables, fruits, milk and milk products, fish, egg, and meat. These supply, in general, proteins, fats, carbohydrates, vitamins, minerals, salts and water. A balanced diet should provide enough food and ensure at least a minimum supply of the essential food factors to maintain life processes in fair working order.

So to have a healthy and productive nation, one has not only to consider increasing the food production but also to assure a balanced diet to the people. To achieve this we have to think in two directions. Firstly, to get the maximum out of the soil and to modify our cropping pattern accordingly and, secondly, to modify our dietetic habits.

To get the maximum out of the soil in the minimum of time, we shall have to confine ourselves to intensive cultivation in limited areas where other facilities are readily available. In these areas we should raise such crops which grow quickly and give high yields per unit area. These are vegetables and some quick-growing fruits. Most of the vegetables, if properly grown, can give a yield which is five to ten times higher than any cereal crop. Moreover, vegetables provide proteins, carbohydrates, mineral salts, vitamins and bulk which along with some cereals and other foods constitute the essentials of a balanced diet.

We can partly tide over the present crisis by immediately putting more area under vegetable cultivation. This will also break the vicious circle by ensuring a better nutritive diet for the people. This is how many European and other countries have solved their food problem. Potato is the staple food in Ireland. More than forty per cent of the diet of a Japanese consists of vegetables. At present, the diet of an average Indian is ill-balanced. It consists mainly of cereals. An average Indian consumes 375g of cereals daily as against 328g per head in the developed countries. While the daily consumption per head of starchy roots and vegetables and fruits in the advanced countries is 316g and 362g respectively, in India it is only 30g and 80g. According to dietitians, an individual should consume about 115g each of leafy and other vegetables and 70g root vegetables daily for a balanced diet. The majority of the population in India being vegetarians, the quantity should be even higher. The present production of vegetables in the country is very low.

These figures show beyond doubt the immediate necessity of increasing the production of starchy roots (potato, sweet potato, tapioca, etc.) and other vegetables and fruits. The development of a sound fruit industry may require some time. So our immediate need is to concentrate on increasing the production of vegetables and quick-growing fruits.

The present knowledge in India regarding the science of vegetable production is scanty. As for successful vegetable production better seeds, improved cultural practices and better plant protection methods are necessary, so also for a successful vegetable industry allied services like transport, marketing, storage and preservation facilities must develop. At present, even correct statistics regarding the area under cultivation of different vegetables, which perhaps should form the basic data for any developmental planning, are not available. Vegetable crops occupy only about 1.2 per cent of the total cultivated area of the country. It is encouraging to note that recently more attention is being paid to increasing the production of vegetables. This is being implemented through crash, emergency and applied nutrition programmes. The available resources if properly developed can not only help in the food self-sufficiency drive but will also provide a means to earn foreign exchange by exporting fresh vegetables and vegetable seeds.

CHAPTER II

Types of Vegetable Gardens

VEGETABLE GARDENS can be classified into six different types according to the purpose for which they have been developed. These are home or kitchen gardens, market gardens, truck gardens, gardens for processing, vegetable forcing and gardens for seed production. The development of each type can be traced to the development of civilisation.

The home or kitchen garden is the most ancient type of garden. When human beings learnt the art of tilling land, they used to live in tribes or colonies and were of a migratory nature. A tribe would go on tilling a piece of land till it was no longer productive and then shift to another virgin land. Each tribe used to grow its own food and these gardens were *kitchen gardens* in the true sense.

As civilisation progressed and expanded, towns and cities came up and new industries were developed. Some people had other occupations than cultivation of land. So one group had to raise food for others who took up other vocations. Thus *market gardens* developed.

These gardens are situated near some town or city markets. With the advancement of civilisation, better and quicker transport facilities developed. So people could select land and other conditions suited to the cultivation of one or two specialised crops. The distance from the market was no barrier so long as good transport facilities were available. These specialised gardens away from the market but having good available means of transport were known as *truck gardens*. Then slowly people gained the knowledge of storing and preserving their surplus products. Big processing factories were set up and a set of gardens around these factories grew up to ensure a continuous supply. These are known as *gardens for processing*.

With further advancement of knowledge, it was possible to grow some vegetables like tomato and cucumber even in seasons when they could not be grown normally. This was made possible by putting up some structures like a glass-house, hot and cold frames. This forcing of vegetables to grow out of their normal season is known as *vegetable forcing*.

Recently, it has been realised that vegetable seed production is a specialised technique. The knowledge of the crop, cultural practices, plant protection measures, harvesting, curing, grading and storage of seed are all specialised techniques. Therefore, gardens have now been developed exclusively for the production of vegetable seeds.

Home or Kitchen Garden

A home or kitchen garden is the type of garden with which individually all are concerned. Whether one lives in a village, town or city, whether one owns land or not, a kitchen garden should be a feature of every home. Of course, the lay-out of a villager's garden will differ from that of a city garden. In the former, a more extensive method of cultivation is followed than in the latter. The village home gardener has certain advantages as he has less limitations of land. Sometimes he may like to use his bullocks and other implements even in the kitchen garden. In the city, land is the limiting factor. So in a city home garden, one would like to produce as much as possible on a small piece of land by following a very intensive method of cultivation. The other advantages that a city gardener enjoys are supply of municipal compost of sludge, supply of municipal water, ready availability of advice and plant protection measures and more reliable sources for purchases of other necessities. With all these advantages, one can produce a good quantity of vegetables even from a small plot.

The real test of technique and interest is in the case of those city-dwellers who do not have any land. This is not uncommon in big cities, with all their multi-storeyed buildings. The enthusiasts have developed another type of garden commonly known as *roof* or *verandah garden*.

Special arrangements are made on the roof to grow vegetables on soils placed on floor after using water-proof cementing. Other vegetables are grown in boxes, pots and such other structures.

Growing vegetables in one's own garden is not only an art but also a continuous training for the person and the family. It not only supplies fresh vegetables but also saves some money as vegetables are now quite costly in the market. It constitutes a very healthy hobby and the spare time of the family is well utilised. A well laid-out and looked-after kitchen garden is a place of pride for the family. Even among the children of the family, it creates a sense of co-operation. The fresh vegetables not only ensure a better balanced diet but there is also a delicate psychology behind the taste. A vegetable grown by oneself will always taste better than the best variety purchased from the market.

Lay-out

A plan for a model kitchen garden of about five cents, suitable for the north Indian conditions, particularly for the plains of Uttar Pradesh, the Punjab and Delhi, has been drawn up, keeping in view the maximum output and a continuous supply of vegetables for the table throughout the year. The broad features of the plan are given below:

The perennial plants should be located on one side of the garden, so that they may not shade other crops, compete for nutrition with annual vegetables or come in the way of proper rotation. Once these perennial vegetables are established, very little care is needed and a constant supply of vegetables will be obtained year after year with little additional cost or labour.

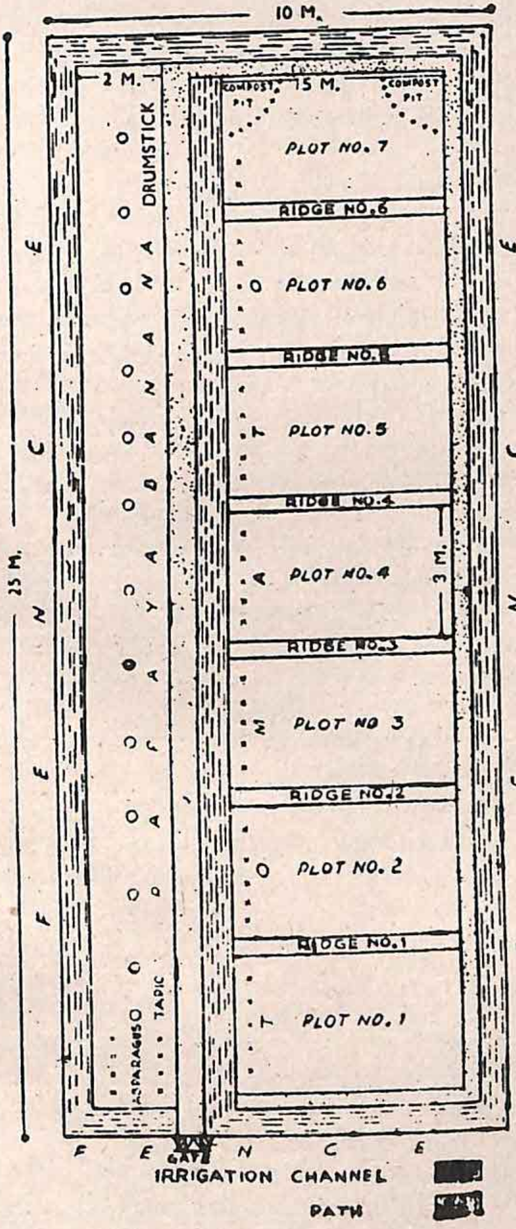
Most economic utilisation of space can be obtained by:

i making use of the fence on three sides for training cucurbits during the summer and rainy season, and peas in winter, and the fourth side for beans;
ii following, continuous crop pattern in the form of succession and companion cropping;
iii utilising the ridges which separate the beds for growing root crops;
iv raising single-stemmed, staked tomato plants on one side and amaranthus and other leafy vegetables on the other side of the footpath; and
v following the principles of crop rotation.

The compost pits are placed in two corners of the garden.

PLAN OF A MODEL KICTHEN GARDEN

(Area 25 x 10 Meter)



They are meant for garden wastes and kitchen wastes, including ash and house sweepings which are to be dumped into them. Bean plants should be trained over these pits to give them shade and also to cut them off from view. All plants which are pulled out after harvest should be invariably put into the compost pits. This will go a long way in obtaining self-sufficiency in manure for the kitchen garden.

Location and Size

In most cases there will be a limited choice for the selection of a site for the kitchen garden. It is usually the backyard of the house. This is itself convenient for several reasons. It enables the members of the family to give constant care to the vegetables during leisure hours. All the waste water from the bathrooms, kitchen, etc. can easily be diverted to the vegetable beds.

The vegetable plots should be located away from trees so that they are not under shade and there is no competition from the wide-spreading roots of trees.

The size of a kitchen garden depends on the availability of land, the number of persons for whom vegetables are to be provided, and the spare time available for its care. It is better to have a small well-kept garden than a large one poorly cared for. By close attention to succession cropping and inter-cropping, five cents of land may be made to supply adequate vegetables for an average family of husband, wife and three children.

Often there may not be any choice in the shape of the garden, but where possible, a rectangular garden is preferred to a square one. A long, narrow plot can be seeded and cultivated in less time than one with shorter rows, where a greater number of turns are necessary.

Crop Arrangement

It is advisable to make a plan before undertaking the planting of a garden. The location of plots, the crops to be grown, the probable dates of planting, spacing between plants, the varieties of each crop to be used, inter-crop and succession planting should be clearly indicated in the plan. Some small notes may be made about each crop every season. By consulting the notes, one may be able to avoid the discrepancies experienced in the previous year.

The final selection of crops, of course, will always depend on individual likes and dislikes. However, it must be borne in mind that a garden should furnish a constant supply but avoid a glut of any one crop except when the surplus can be home-canned.

A cropping pattern which may prove helpful for kitchen gardens in Delhi is suggested below:

	Name of Vegetable	Time
Plot 1	Cabbage inter-cropped with lettuce	November-March
	Cluster bean and French bean	March-October
Plot 2	Cauliflower (late) inter-cropped with knolkhol	September-February
	Cowpea (summer)	
	Cowpea (rainy season)	March-August
Plot 3	Cauliflower (mid-season)	July-November
	Radish	November-December
	Onion	December-June
Plot 4	Potato	November-March
	Cowpea	March-June
	Cauliflower (early)	July-October
Plot 5	Brinjal (long) with spinach as inter-crop	July-March
	Bhindi with amaranth as inter-crop	March-June
Plot 6	Brinjal (round) with spinach as inter-crop	August-April
	Bhindi with amaranth as inter-crop	May-July
Plot 7	Chillies	September-March
	Bhindi	June-August
Ridges 1 to 3	Turnip followed by radish	
Ridge 4	Beet followed by colocasia	
Ridges 5 and 6	Carrot followed by colocasia	
Ridge 7	Radish varieties followed by colocasia	
Perennial plot	The following plants can be grown:	
	Drumstick	One in a row
	Banana	Five in a row
	Papaya	Five in a row
	Tapioca	Two in a row
	Curry leaf	One in a row
	Asparagus	Two small rows

The space on both sides of the path can be utilised for growing rows of leafy vegetables, ginger, etc.

Bean plants should be trained on the gate side of the fence. On the remaining three sides, peas can be trained followed by cucurbits like bitter gourd, ridge gourd, sponge gourd, snake gourd, squash melon, cucumber and *kakri* in summer.

A daily supply of 1.5 kg of fresh vegetables can be assured from the above garden. The cost of seed per year will be about Rs 20.

The following table shows the different kinds and varieties of vegetables that can be grown in kitchen gardens in Delhi, with necessary information on seed requirements and estimated yields of vegetables, the unit of area being 250 sq m.

Estimated Yields of Vegetables from a Five-Cent Kitchen Garden

Crop	*Variety*	*Seed required*	*Estimated yield in kg*
Chilli	N.P. 46 A or Jwala	1 pkt[1]	7
Onion	E. Grano	45 g	25
Onion	Pusa Red	45 g	20
Bhindi	Pusa Sawani or Parbani Kranti	90 g	40
Brinjal	Pusa Purple Long	1 pkt	30
Brinjal	Pusa Kranti	1 pkt	25
Cauliflower	Pusa Katki	1 pkt	20
Cauliflower	Pusa Deepali	1 pkt	25
Cauliflower	Snowball	1 pkt	20
Radish	Rapid Red White Tipped	1 pkt	30
	Japanese White	1 pkt	
	Pusa Desi or Pusa Chetaki	1 pkt	
	White Icicle or Pusa Himani	1 pkt	
Potato	Kufri Alankar, Kufri Sindhuri Kufri Chandramukhi, Kufri Bahar	4 kg	50
Cowpea	Pusa Phalguni	½ kg	50
	Pusa Dofasli	1 kg	50
Cabbage	Golden Acre	1 pkt	30
	Drumhead	1 pkt	
Cluster bean	Pusa Naubahar	1 pkt	10
French bean	Contender or Pusa Parvati	350 g	
Carrot	Nantes	1 pkt	7
Beet	Crimson Globe	1 pkt	5

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[1] Each packet of seed is worth about 30 paise.

Crop	*Variety*	*Seed required*	*Estimated yield in kg*
Turnip	Purple Top White Globe or Snowball	1 pkt	10
Knolkhol	White Vienna or Pusa Chandrima	1 pkt	7
Lettuce	Great Lakes	1 pkt	2
Colocasia	Local	4 kg	30
Spinach	Virginia Savoy, Early Smooth Leaf	30 g	10
Palak	Pusa Jyoti		
Amaranthus	Any variety	60 g	.7
Bottle gourd	Pusa Meghdoot or Pusa Manjari	1 pkt	15
Pumpkin	Local	1 pkt	15
Sponge gourd	Pusa Chikni	1 pkt	15
Ridge gourd	Pusa Nasdhar	1 pkt	15
Cucumber	Straight Eight, Poinsety or Japanese	1 pkt	5
Peas	Long Green Bonneville	½ kg	
	Arkel	½ kg	40
Dolichos bean	Pusa Early Bunching	1 pkt	7
Tomato	Sioux, Pusa Ruby or Pusa 120	1 pkt	25
		Total estimated yield	**597**
		Average quantity of vegetables per day	**1.5 kg**

Market Garden

This is the type of garden which produces vegetables for the local market. Earlier when quick transport did not develop, this type of garden was confined to the immediate vicinities of cities. Most of the market gardens even today are located within 15 to 20 km of a city. The cropping pattern in these gardens will depend on the demands of the local market. The land being costly, intensive methods of cultivation are followed. A market gardener will like to grow early varieties to catch the early market. He must be a versatile person as he will have to grow a number of vegetables throughout the year. He should also be a good salesman as he may have to sell his own produce. The high cost of land and labour is compensated by the availability of municipal compost, sludge and water near some cities and high return on the produce.

Truck Garden

This is the type of garden which produces special crops in relatively large quantities for distant markets. Truck gardens in general follow a more extensive and less intensive method of cultivation than market gardens. The word 'truck' has no relationship with a motor truck but is derived from a French word *troquer* meaning 'to barter'. The commodities raised are usually sold through middlemen. The location of this type of garden is determined by the soil and climatic factors suitable for raising particular crops. The truck gardener should be a specialised person. He should be proficient in the large-scale production and handling of some special crops. The cost of land may be cheap and cheap labour may be available. He follows the mechanised method of cultivation. His cost of cultivation is, therefore, less. The net income is also less as this includes the cost of transport and the charges of the middleman. With the development of a quick and easy transport system, the distinction between the market and truck gardens is continuously diminishing.

Vegetable Garden for Processing

This is a type of garden which comes up around vegetable processing factories. These gardens are mainly responsible for the regular supply of vegetables to the factories. This type of garden has not yet developed in India. The reason is lack of the development of the processing industry. The few factories which exist depend on purchases from local markets. The end product cannot be very good from such heterogeneous mixture. The prospects of future development are quite bright as the people's interest in the processing industry is growing. These gardens specialise in growing only a few vegetables in bulk. They choose a heavier soil since their main consideration is a high and continuous yield rather than an early yield. These gardens are required to grow the particular varieties suited for canning, dehydration or freezing. The prices are paid on contract basis on weight and quality of the product. The return may be low but the cost of marketing and the transport charges are negligible.

Vegetable Forcing

This type of garden is concerned with the production of vegetables out of their normal season. The most common forcing structures are glass-houses or glass-frames. The vegetables commonly grown under these are tomato and cucumber. These are mostly used during winter in the temperate regions. Crops like cucumber and tomato cannot be grown outside during cooler months and, as they are required throughout the year, they are grown under protection. The other vegetables which are produced in cellars, caves and special sheds are mushroom, rhubarb and asparagus. Special varieties have been developed which do better under these structures. In India this type of garden has very little chance to develop. The country being so large and the transport facilities being well organised, all vegetables can be grown normally throughout the year in one part or another. Moreover, the purchasing capacity of the general people being low, they will not be able to pay the extra cost incurred to force vegetables out of season. The starting of the summer vegetables on riverbeds during winter months with the help of organic manure and windbreaks of dry grass is also a type of vegetable forcing. Sometimes for an early produce seedlings of crops like tomato or brinjal are forced to germinate in small protected structures. This may also be regarded as a type of vegetable forcing.

Vegetable Garden for Seed Production

Good seed is the base of any successful farming industry. Seed production is rather a specialised field of vegetable growing. Soil, climate and disease-free conditions are factors influencing location of seed-producing areas. A thorough knowledge of the crop, its growth habit, mode of pollination, proper isolation distance are all of prime importance. The handling of the seed crop, curing, threshing, cleaning, grading, packing and storage—all need specialised knowledge. Generally, the nucleus or breeder's seed is produced by the person or organisation which gives out the variety. The foundation seed is multiplied by the Government departments or by organisations like the National Seeds Corporation. The third and the fourth stages of multiplication, that is, registered and certified seeds, are usually multiplied by growers. This is an expanding industry in India and has a good future. India has varied climatic conditions extending from the temperate Himalayas to the tropical south. All the vegetable seeds can be profitably grown here. There is a big potentiality of exporting vegetable seeds to foreign countries.

India at present does not import any vegetable seeds. To expand foreign trade in this industry, the quality of seeds produced must be raised. The Indian Parliament took this into consideration and passed the Seeds Act.

Floating Vegetable Garden

One more type of vegetable garden known as a 'floating garden' is seen on the Dal Lake of the Kashmir valley. Most of the summer vegetables are supplied to Srinagar from these gardens. A floating base is first made from the roots of Typha grass which grows wild in some parts of the Lake. Once this floating base is ready, seedlings are transplanted on leaf compost made of the vegetation growing wild in the Lake. All the intercultural operations and occasional sprinkling of water are done from boats. This type of vegetable cultivation is a specialised technique and an art in itself.

CHAPTER III

Classification

THERE ARE more than fifty individual vegetables. If the method of growing each is dealt with in detail, it is likely to make things complicated and cause a lot of repetition. To eliminate this avoidable repetition, it is desirable to classify the vegetables in some groups. This grouping or classification is mainly to show the relationship between the individual vegetables and to avoid repetition while describing their cultural operations.

If the vegetables are arranged in the alphabetical order, this neither shows any relationships nor helps in describing the principles of culture. Generally, four methods of classification are followed. They are: (1) botanical classification, (2) classification based on hardiness, (3) classification based on parts used, and (4) classification based on essential methods of culture.

Botanical Classification

This is a method of classification based on relationship which exists among the different vegetables. Plants are first divided into four sub-communities. They are Thallophyta, Bryophyta, Pteridophyta and Spermatophyta. All the vegetables come under the sub-community Spermatophyta which includes two divisions: Gymnospermae and Angiospermae. No vegetable belongs to the division Gymnospermae. Angiospermae has two classes: Monocotyledoneae and Dicotyledoneae. These are further divided into families, genus, species, sub-species and botanical varieties. The grouping of vegetables is as follows:

MONOCOTYLEDONEAE

Family—AMARYLLIDACEAE

Allium cepa	Onion
Allium cepa var. *aggregatum*	Multiplier onion

Allium cepa var. *viviparum*	Top onion
Allium porrum	Leek
Allium sativum	Garlic
Allium fistulosum	Welsh onion
Allium ascalonicum	Shallot
Allium schoenoprasum	Chive
Family—LILIACEAE	
Asparagus officinalis	Asparagus
Family—ARACEAE	
Colocasia esculentun	*Arvi* or Dasheen
Family—DIOSCOREACEAE	
Dioscorea alata	Yam
DICOTYLEDONEAE	
Family—AIZOACEAE	
Tetragonia expansa	New Zealand spinach
Family—CHENOPODIACEAE	
Beta vulgaris	Beetroot and *Palak*
Beta vulgaris var. *cicla*	Swiss chard
Spinacia oleracea	Spinach
Family—COMPOSITAE	
Cichorium intybus	Chicory
Cichorium endivia	Endive
Lactuca sativa	Lettuce
Cynara scolymus	Artichoke
Family—CONVOLVULACEAE	
Ipomoea batatas	Sweet potato
Family—CRUCIFERAE	
Brassica oleracea var. *acephala*	Kale
Brassica oleracea var. *gemmifera*	Brussels sprouts
Brassica oleracea var. *capitata*	Cabbage
Brassica oleracea var. *botrytis*	Cauliflower
Brassica oleracea var. *italica*	Sprouting broccoli
Brassica caulorapa	Kohlrabi or knolkhol
Brassica napus var. *napobrassica*	Rutabaga

Brassica campestris var. *rapa*	Turnip
Brassica juncea	Mustard
Brassica pekinensis	Chinese cabbage
Brassica chinensis	Chinese cabbage
Armoracia rusticana	Horse radish
Raphanus sativus	Radish
Family—CUCURBITACEAE	
Cucurbita pepo	Summer squash
Cucurbita moschata	Pumpkin
Cucurbita maxima	Winter squash
Citrullus lanatus	Watermelon
Cucumis melo	Muskmelon
Cucumis sativus	Cucumber
Sechium edule	Cho-Cho
Luffa acutangula	Ridge gourd
Luffa cylindrica	Sponge gourd
Lagenaria siceraria	Bottle gourd
Momordica charantia	Bitter gourd
Citrullus vulgaris var. *fistulosus*	*Tinda*
Trichosanthes dioica	*Parwal*
Trichosanthes anguina	Snake gourd
Family—EUPHORBIACEAE	
Manihot esculenta	Tapioca
Family—LEGUMINOSAE	
Pisum sativum	Peas
Phaseolus vulgaris	French bean
Phaseolus lunatus	Lima bean
Vicia faba	Broad bean
Vigna sinensis	Cowpea
Vigna sinensis var. *sesquipedalis*	Asparagus bean
Dolichos lablab	Bean
Glycine max	Soybean
Psophocarpus tetragonolobus	Winged bean
Family—MALVACEAE	
Abelmoschus esculentus	*Bhindi*
Family—POLYGONACEAE	
Rheum rhaponticum	Rhubarb

Rumex vesicarius	Sorrel
Family—SOLANACEAE	
Solanum tuberosum	Potato
Solanum melongena	Brinjal
Lycopersicon esculentum	Tomato
Capsicum annuum	Chilli and sweet pepper
Family—UMBELLIFERAE	
Daucus carota	Carrot
Petroselinum crispum	Parsley
Apium graveolens	Celery
Pastinaca sativa	Parsnip

This method of classification, of course, gives a very good base to study the relationship that exists between groups of different vegetables. This does not, however, give the final solution of avoiding repetition. The cultural operations of the vegetables belonging to the same family are not always similar. For example, the cultural operations for potato differ from those for tomato or brinjal. The requirements of carrots are quite different from those of celery. Therefore, some other method of classification which may give some more information was tried.

Classification Based on Hardiness

All vegetables are roughly placed into two groups according to their temperature requirements. They are thus broadly known as winter and summer vegetables. The winter or cool-season vegetables are those of which the vegetative parts—roots, stems, leaves and buds or immature flowers—are eaten. There are two exceptions to this rule which are warm-season crops—sweet potato and New Zealand spinach. Those vegetables of which the immature fruits are eaten are warm-season crops. Pea and broad bean are exceptions, being cool-season crops. According to average temperature requirements, the crops can be placed in further smaller groups. However, within any one crop there may be some varietal differences in the temperature requirements.

Minimum monthly average, —1° C
Asparagus, rhubarb

Optimum monthly average, 12-22° C
(Maximum average, 22° C; minimum average, 5° C)
Chicory, garlic, leek, onion, shallot

Optimum monthly average, 15-17° C
(Maximum average, 22° C; minimum average, 5° C)
Beet, broad bean, broccoli, Brussels sprouts, cabbage, kohlrabi, radish, spinach and turnip
Optimum monthly average, 15-17° C
(Maximum average, 20-22° C; minimum average, 7-5° C)
Artichoke, carrot, cauliflower, celery, chicory, chinese cabbage, lettuce, parsley, pea, potato
Optimum monthly average, 20-22° C
(Maximum average, 33° C; minimum average, 10° C)
Cowpea, New Zealand spinach

Optimum monthly average, 20-22° C
(Maximum average, 25° C; minimum average, 17° C)
Tomato, sweet pepper

Optimum monthly average, 20-27° C
(Maximum average, 33° C; minimum average, 17° C)
Brinjal, chilli, *bhindi*, sweet potato, watermelon, bottle gourd, pumpkin, muskmelon, bitter gourd

This method of grouping gives us information about the right time of sowing the crops and their temperature requirements. The cultural requirements of all the vegetables grouped as winter-season vegetables are not the same, so is the case with the summer-season crops. Thus this method of classification does not fulfil the requirements.

Some try to place vegetables in groups according to their requirements of soil reaction. The crops are divided into three groups—those which are slightly tolerant to acid soils, those which are moderately tolerant and those which are very tolerant. The table below shows the grouping:

Slightly tolerant (pH 6.8 to 6.0)	*Moderately tolerant (pH 6.8 to 5.5)*	*Very tolerant (pH 6.8 to 5.0)*
Asparagus	Bean	Chicory
Beet	Brussels sprouts	Endive
Broccoli	Carrot	Potato
Cabbage	Cucumber	Rhubarb
Cauliflower	Brinjal	Sweet potato
Celery	Garlic	Watermelon
Palak	Horse-radish	
Chinese cabbage	Kohlrabi	
Leek	Parsley	
Lettuce	Pea	
Muskmelon	Pepper	
New Zealand spinach	Pumpkin	
Bhindi	Radish	
Onion	Squash	
Spinach	Tomato	
	Turnip	

Though this method gives us information about a particular aspect, it does not fulfil the objectives of classification. Therefore, often some other method of classification is tried.

Classification Based on Parts Used as Food

In this system of classification, vegetables are grouped according to the parts which are eaten. The crops which are grown for the consumption of the leaves or stems are classed in one group. This group includes cabbage, kohlrabi, asparagus, salad crops and all the potherbs and greens. All vegetables grown for their edible fruit such as tomatoes, brinjals, peas, *bhindi*, beans and cucurbits are classed in the second group. Those crops which are grown for their flower parts like broccoli and cauliflower are placed in the third group. In the last group are placed those crops which are grown for their underground parts, such as potato, sweet potato, beet, carrot, radish, turnip, onion, garlic, colocasia and tapioca. The cultural operations for crops in each group are not the same. The requirements of cabbage, asparagus and salad crops are quite different; the same is true for tomato, *bhindi* and cucurbits. So this system is also not of much value when the basic idea of classification is taken into consideration. So a more suitable method of classification is often tried.

Classification Based on Methods of Culture

This is a very convenient method. In this method all vegetable crops having more or less similar cultural requirements are grouped together. This makes it possible to give the general cultural practices for the group without the necessity of repetition while describing the individual crop. This method in fact combines some parts of the other three methods. Some groups like cucurbits, cole crops, bulb crops not only have similar cultural requirements for the group but the crops in each group also belong to the same family. In groups like potherbs or greens, salad crops, bulb crops, the parts eaten as vegetables in each group are also the same. Most of the crops belonging to the bulb or salad group also have similar temperature requirements. Thus this method of classification even though not in all but in the majority of cases fulfil the basic requirements of classification of vegetables. This method has been largely used in almost all textbooks and has also been followed in this book. The vegetables described in this book have been dealt under the following groups:

Group 1	Potato
Group 2	Solanaceous fruits
Group 3	Cole crops
Group 4	Root crops
Group 5	Bulb crops
Group 6	Peas and beans
Group 7	Cucurbits
Group 8	Sweet potato
Group 9	*Bhindi* or okra
Group 10	Salad crops
Group 11	Potherbs and greens
Group 12	Other root crops
Group 13	Perennial vegetables

CHAPTER IV

Potato

(Solanum tuberosum L.)
Hindi : *Alu*

THE POTATO, a native of South America, has been under cultivation in the Andes and Chilean highlands of that continent for over a thousand years. The annual production of potato in the world surpasses that of all other vegetables with considerable margin and ranks with wheat and rice. In India, the potato has been cultivated since its introduction in the early part of the 17th century. The cultivation of potato has not spread in India as it should have done. This is apparent when the consumption rate of about 100-170 kg per capita per annum in several countries of the West is compared with 13 kg of potatoes consumed per capita in India. The area under potato in India in 1980 was 790,000 hectares with an annual production of about 1,07,25,000 tonnes. The area and the production are on the increase.

In a country with limited resources, where the nutrition level of the population has to be maintained under inhospitable situations, the potato has a special value as a food. The table below gives the food value of the potato:

(per 100 g of edible portion)

Moisture	74.7	g	Iron	0.7	mg
Protein	1.6	"	Sodium	11.0	"
Fat	0.1	"	Potassium	247	"
Minerals	0.6	"	Copper	0.20	"
Fibre	0.4	"	Sulphur	37	"
Other carbohydrates	22.6	"	Chlorine	16	"
Calories	97		Vitamin A	40	I.U.
Calcium	10	mg	Thiamine	0.1	mg
Magnesium	20	"	Riboflavin	0.01	"
Oxalic acid	20	"	Nicotinic acid	1.2	"
Phosphorus	40	"	Vitamin C	17	"

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Taxonomy and Varieties

The potato belongs to the family Solanaceae, genus *Solanum* and species *tuberosum*. There are many related species both tuberous and non-tuberous. There are many varieties of potatoes either introduced into or bred in India. Some of the important varieties are described below:

Satha: It is an early variety and becomes ready in about 2 to 2½ months. This variety is grown in Bihar. The yields are low but can be remunerative owing to high prices of the early market.

Gola: The commercial 'Gola' is a mixture of three varieties, of which 'Gola B' is dominant and has large, pear-shaped, white tubers with deep-set eyes. The flesh is cream-coloured. This is an early variety.

Up-To-Date (Disease-free clone): It is an early maturing variety (90 days) and is adapted to a wide range of environmental conditions and is particularly suited for Uttar Pradesh, Himachal Pradesh, the Punjab, Madhya Pradesh, Bihar and Maharashtra. Its tubers are of a large size, have a smooth surface, an oval and flattened shape, fleet eyes and white flesh. It is one of the most popular varieties in cultivation in India.

Phulwa: It is probably an old European potato variety which has lost its identity. It has been under cultivation in this country for more than a century. It produces a good yield under a wide range throughout north India. The tubers are small to medium, skin smooth, colour white, shape round, eyes moderate in number, deep flesh, colour yellow. It keeps well. It is a late maturing variety.

Darjeeling Red Round: It is slightly earlier than Phulwa. It has also a wide adaptability. The tubers are medium-sized, round with deep red-coloured eyes. It does not keep as well as Phulwa.

Kufri Red: This clonal selection from Darjeeling Red Round was first released in 1957. This variety gives excellent yields in the plains and is particularly suited for U.P., Bihar and West Bengal. Its tubers are of medium size, have a smooth and red skin, round shape, yellow flesh and medium deep eyes. It has a good keeping quality under ordinary conditions.

Kufri Kuber: This variety is suited for both the plains and the hills of Maharashtra, the Punjab and Bihar. It is also suitable as an early and main crop variety. It yields fairly well under long days, but tuberises better under short-day conditions. The tubers are of medium size, have smooth surface, oval, flattened shape, fleet eyes and white flesh and skin.

Kufri Kisan: This is a late maturing variety and gives heavy yields in the plains. It is particularly suitable for Uttar Pradesh, Madhya Pradesh, Delhi and the Punjab. The tubers are of medium size, with a smooth surface, deep eyes, white skin and round shape. It has a very good keeping quality.

Kufri Kundan: It is an alternate variety to Up-To-Date. This is particularly suitable for hill areas, heavy and wet soils. It performs well under long-day conditions in the hills. It has tubers of medium size, having a smooth surface, round shape, white skin, fleet eyes and yellow flesh. It has excellent keeping qualities.

Craig's Defiance: This variety was introduced from the United Kingdom in the year 1953. It is suited for culture in the hill areas of Himachal Pradesh and the Punjab. The tubers of this variety are of a large size, have a smooth surface, long shape, white skin colour, fleet eyes and white flesh.

Kufri Safed: A late (4½ to 5½ months) variety. It producers small, round, white tubers with deep eyes and a light, creamy-yellow flesh. A clonal selection of Phulwa, it is an excellent substitute for the latter. It is a hardy variety, suitable for a poor soil, with meagre facilities of irrigation. It has an excellent keeping quality. It is recommended for the plains of Uttar Pradesh.

Kufri Kumar: A late maturing (4½ to 5½ months) variety, with large, white, oblong tubers. It is a good yielder both in the hills and on the plains and possesses a high degree of field resistance to late blight. It has, therefore, been recommended for the hills, particularly where late blight is a problem.

Great Scot: Introduced from England by the Madras Department of Agriculture, it is an early (3 to 3½ months) variety with oval, white tubers. It is very popular in the Nilgiri Hills because of its ability to give high yields and rapid bulking under conditions prevailing there. It is however, susceptible to late blight, mosaic and leaf-roll viruses and other diseases.

President: Introduced from England, it is a medium maturing

(3½ to 4½ months) variety with round, white tubers. This variety is also grown in the Nilgiri Hills. It is field resistant to blight. A clone of this variety has recently been selected at the Central Potato Research Institute. This clone has given a better performance than the parent variety and has been named as the President-Kufri clone.

Kufri Neela: A late maturing (4½ to 5½ months) variety with round, white tubers. As a substitute for Great Scot, it has several virtues. It answers the trade needs and possesses Great Scot type of tubers. Besides, it yields about 70 per cent higher than Great Scot. The greatest value of this variety is that it is resistant to late blight, which, in recent years, has limited potato culture in the Nilgiri Hills.

Newly-improved Varieties

Kufri Sindhuri: Medium maturing (3½ to 4½ months) with round, light red medium-sized tubers. It is suitable for cultivation as a main crop variety in the plains, as a replacement to Kufri Red and other late varieties.

Kufri Chandramukhi: Early maturing (matures 10 days earlier than Up-To-Date), with attractive oval, white tubers. It degenerates slowly and keeps well in storage. It gives high yields (higher than Up-To-Date) and cooks easily and does not degenerate rapidly in the plains

Kufri Khasi-Garo: An early maturing variety, possessing a good degree of field resistance to late blight and moderate resistance to early blight and viruses, fit for growing in the hilly regions of Assam.

Kufri Naveen: A fertilizer-responsive variety for the Khasi Hills region of Assam; possesses a high degree of field resistance to late blight, resistance to wart and moderate resistance to *Cercospora* leaf spot and early blight.

Kufri Chamatkar: An early bulking variety (110-120 days) with uniform-sized, shining and smooth tubers; suitable for the Punjab, Haryana, Uttar Pradesh and Madhya Pradesh.

Kufri Neelmani: Suited for the Nilgiri Hills in the south. It has given 100 per cent more yields than the variety Great Scot, which has long been popular in the Nilgiri area. The new variety can be grown in all the three potato crop seasons in that area.

Kufri Sheetman: A frost-resistant variety, suitable especially for the Punjab, Rajasthan, Haryana and Uttar Pradesh as also for Madhya Pradesh and West Bengal. It can be planted late in the northern plains owing to its high degree of resistance to frost.

Kufri Jyoti: A widely adaptable fertilizer-responsive variety, possessing a high degree of field resistance to late blight disease in the foliage and also a good degree of tuber resistance to the same disease. This variety is also resistant to the wart and moderately resistant to *Cercospora* leaf spot. It is recommended for Himachal Pradesh and Kumaon Hills of Uttar Pradesh.

Kufri Alankar: A very early tubering (75 days), photo-insensitive variety capable of giving high yields, suitable for cultivation in the plains of northern India. This variety, by virtue of its earliness, can be included in the multiple cropping patterns which are coming into vogue with with the introduction of the short-duration, dwarf, high-yielding varieties of rice and wheat.

Kufri Jeewan: A late-maturing, high-yielding variety, possessing a high degree of field resistance to late blight, resistance to the wart and *Cercospora* leaf spot disease. It is recommended for cultivation in Himachal Pradesh.

Kufri Moti: It is suitable for growing in the Nilgiri Hills. The tubers are oval, white and round and takes 110-120 days to mature. It is field immune to race 1 of late blight.

Kufri Lauvkar: It is an early maturing variety (Plateau—70; Plains—100 days) with round white tubers and light cream and firm flesh. It is suitable for growing in the Deccan Plateau in Maharashtra.

Kufri Dewa: It is recommended for growing in the Tarai area of Western Uttar Pradesh. The tubers are oval round and white with yellow flesh and takes about 130 days for harvest in the plains and 150-160 days in the hills.

Kufri Badshah: is suitable for cultivation in the Indo-gangetic plains including Punjab, Haryana, U.P., Bihar, West Bengal, Madhya Pradesh and the Deccan Plateau. It has also performed well in north western Himalayan region. It matures in 90-100 days. It bears mostly large to medium size oval-round white tubers. It is resistant to late blight, early blight and PVX. It is moderately resistant to *Phoma* blight. It is tolerant to frost. It gives higher yield than Kufri Chandramukhi and Kufri Sindhuri in plains and comparable yield with Kufri Jyoti in the hills.

Kufri Bahar: is high yielding and is suitable for cultivation in Punjab, Haryana and western U.P. It matures in 100-110 days in the plains having large white, round tubers with white flesh, smooth skin and medium deep eyes. It has high dry matter content and good cooking qualities.

Kufri Sherpa: is resistant to wart and late blight diseases and gives higher yield than other commercial varieties being grown in the West Bengal hills.

Kufri Himalini: is suitable for north-eastern hills of Meghalaya, Khasi and Jaintia Hills, Nagaland, etc. In these areas many complex races of late blight pathogens have broken down the resistance of the earlier variety Kufri Jyoti. The new variety has performed equally well in the hills of Himachal Pradesh, West Bengal, Uttar Pradesh and the Nilgiris.

Kufri Lalima: is recommended for those areas, where red-tubered varieties like Kufri Sindhuri are preferred and where winters are short. This variety has a fast bulkind rate and out-yields Kufri Chandramukhi at 75 days harvest. When grown to full maturity it gives higher yields than Kufri Sindhuri. This variety has a very wide adaptibility and is suitable for Uttar Pradesh, Bihar, West Bengal, Orissa and Madhya Pradesh.

Kufri Muthu: is a late blight resistant variety, and is especially suitable for cultivation in Nilgiri Hills of southern India. It has short dormancy period and thus three crops can be taken with the same stock.

Climate and Soil .

The potato has a wide range of seasonal adaptability. It is a cool season crop and is moderately tolerant to frost. The young plants grow best at a temperature of 24°C. Later growth is favoured at a temperature of 18°C. Tuber production is maximum at 20°C and decreases with the rise of temperature. At about 30°C the tuber production stops totally. Short days are beneficial for tuber production. Temperature may upset the effect of photoperiod. Varieties differ considerably in their response to varying photo-periods. In general, the early-maturing varieties are favoured by relatively large days, whereas late varieties are better adapted to short days during the period of tuber development.

The tuber is borne underground at the stolon-ends. So soils which are naturally loose offer the least resistance to the enlargement of the tubers. It is also generally assumed that aeration of soil has a great effect on tuber set and tuber development. The potato can be grown almost on any type of soil. Excellent potato crops can be grown under the river-bed system of cultivation. On the other hand, rice-potato and jute-potato are established rotations practised in West Bengal. The ideal soil for potato is one which is well drained, well aerated, deep and having a pH range of 5.2 to 6.4. Alkaline soils create favourable conditions for scab disease.

Seed

The potato is propagated from tubers which are commonly spoken of as seeds. Tubers are planted either whole or cut into pieces. Many diseases are carried by seed potatoes. Maximum yields are not obtained unless the seed is free from disease, is of a suitable variety, free from mixtures, grown under favourable climatic conditions and firm and sound with sprouts just beginning to show when planted. Certified seeds should be preferred. Immediately after harvest the tubers have a rest or a dormant period of 2 to 3 months. The dormancy can be broken by treating the tubers with thiourea, ethylene chlorohydrin or potassium thiocynate. The usual size of seed piece is 40 to 50g with 40 to 50 mm diameter. The seed rate varies with the size of tuber. It varies from 800 to 1500 kg per hectare.

Sowing Time

In the plains of north India, the sowing time can be extended from mid-September to almost mid-January. Late sowing may however give low yield. In the Punjab, Rajasthan, Delhi and

Western Uttar Pradesh, two crops in succession can be raised on the same land. In south India and the Chotanagpur region of Bihar, where summer temperatures in the plateau region are somewhat low, two crops—a *rabi* and a *kharif* crop—can be raised. In the Nilgiri Hills, three potato crops are raised in succession, the planting times being April, August and January. In the hilly regions of north India the crop is sown in March-April.

Spacing

Forty-five to 60 cm × 15 to 25 cm according to the variety and size of seed tuber.

Soil Preparation, Manures and Fertilizers

Being a shallow-rooted crop, the potato gets most of its requirements from surface soil. As a heavy crop is produced within a limited time, this crop has a high nutrient requirement. A yield of 25 tonnes per hectare of tuber removes 110 kg of nitrogen, 50 kg of phosphate and 225 kg of potash. In light soils and places where organic manures are not easily available, green manuring proves beneficial.

Well-rotten farmyard manure or compost at the rate of about 30,000 kg per hectare is incorporated in the soil three to four weeks before planting. Four hundred kg of ammonium sulphate, 500 kg of single superphosphate and 140 kg of potassium sulphate per hectare should be applied in furrows at planting time. Two hundred kg of ammonium sulphate should then be top-dressed just before the earthing-up. If urea is to be applied instead of ammonium sulphate, high doses should be avoided at the time of sowing. This may affect germination.

Interculture

The main object of interculture is to keep the soil loose and destroy weeds. The first earthing-up should be done when the plants are about 15 to 25 cm high. The second earthing-up is often required later to cover up the tubers properly.

Irrigation

The potato being a shallow-rooted crop needs irrigation at frequent intervals. The interval is decreased when tubers are formed. The best results are obtained by irrigating when the soil moisture has dropped to 50 per cent of field capacity. A seasonal total of 12 to 24 acre inches of water in about six applications is usually sufficient.

Weed Control

Many chemical weedicides are now recommended. 2, 4-D, a cheap chemical may be used. 1.3 kg of acid equivalent of 2, 4-D per hectare applied eight days after planting potatoes is effective in controlling weeds. Chemicals like Linuron or Simazine at 0.5 kg per hectare applied as a pre-emergence spray are also effective. Simazine should not be used if wheat is to follow potato. Tok E-25 or Lasso 2 litre/ha can also be used.

Harvesting

The time of harvest is very important in potato. The development of tuber continues till the vines die. Potatoes are harvested from the time they are of sufficient size until the vines have fully ripened. The loss in yield due to early harvest usually is compensated by high-priced market. On the other hand, immature potatoes shrink severely, bruise easily and will not keep well. Care should be taken at the time of harvest to save the tubers from injury. The tubers immediately after harvest should not be left in the scorching sun. Otherwise they develop sunscalds within the next 18 to 36 hours. It first appears in limited areas. The skin over the injured areas become watery in appearance, with a narrow, darker area around the margin. If the tubers are stored at 15°C, it helps in healing up of the tubers suffering from sunscalding.

Yield

The yield varies from variety to variety. However, the average yield of the early-maturing varieties is about 200 quintals and that of the late varieties about 300 quintals per hectare. Yields as high as 500 to 600 quintals per hectare are also not rare. The average yield of potato in India is only 84 quintals per hectare.

Storage

The best method of storing potatoes is in cold storage.

Unfortunately, the number of cold storage plants in India is limited and local and indigenous methods are quite common. The two methods generally used are room storage and pit storage.

Room Storage—The room should have a high plinth and good ventilation. The doors and ventilators should be fitted with insect-proof wire-nets. Potatoes can be stored in single layers on sand. Frequent examination is necessary to discard tubers showing rotting symptoms.

Pit Storage—In this system the tubers are stored in pits 60 to 75 cm deep and 2.5 m long and 1 m wide. These pits are made in some cool shady place. Water is sprinkled inside the pit to cool it. After two days neem leaves, dry grass or sugarcane trash is lined all round the pit inside. Bamboo chimneys of 1.5 m length are placed inside the pit 1 m apart for facilitating evaporation of the moisture deposited due to transpiration of the stored tubers. Pits are then filled with tubers leaving 15 cm on top followed by a one-foot layer of dry grass. A thatch is provided over the pit as protection from rain and sun.

Cold Storage—This is the best method of storing potatoes. Temperature and humidity are regulated in such storage. Best temperature and humidity conditions for potatoes are 2.2°C to 3.3°C and 75 to 80 per cent relative humidity. Potatoes stored at less than 0°C suffer from internal breakdown known as "Black Heart". Potatoes are spread over the shelf to a thickness of not more than 30 cm. Individual shelves are about 45 cm high and 15 cm space is allowed between two layers.

Tubers stored in cold temperature should be kept for 12 to 24 hours at 15° C before being exposed to atmospheric conditions. This ensures proper germination.

Physiological Changes During Storage

Rapid Periderm Formation—If the tubers are kept at 15 to 20°C after harvest, periderm formation is rapid. The rapidity is affected by the variety, temperature, humidity and maturity of tubers. Usually effective periderm formation is complete within the first two weeks. If the tubers are kept immediately after harvest in cold storage, at 5°C, the periderm formation is delayed. So for long storage, the tubers should be kept at 15-20°C for the first two weeks.

Starch-Sugar Balance—This is affected by maturity, season, variety and storage conditions. High starch and low sugar content are desirable. When a tuber is kept at 10°C, it will have a low sugar content till the storage of tubers is terminated by sprouting. If the temperature is lowered, more sugar is formed.

Sprouting—Sprouting is often a serious problem in storage of potatoes. It is affected by temperature, humidity, variety and maturity. A pre-harvest spray of maleic hydrazide (0.3 per cent) controls the sprouting.

Insect Pests and Their Control

The potato is attacked by a large number of insects of which only a few are important.

Aphids—There are several kinds of aphids or plant lice, that feed on potato plants. Aphids transmit a virus disease and cause severe damage to the plant by sucking the juice from leaves and young stems. The plants may be stunted, with the leaves tightly curled and rolled when the attack is severe. Aphids are controlled by spraying with parathion, malathion or nicotine sulphate. The spraying should be repeated every week till the insect is completely controlled. Metasystox 25EC and Rogor 30EC @ 1.0 litre and 0.75 litre respectively in 1,125 litres of water per hectare gives good control.

Leaf Hoppers—These insects are pale-green and about one-fourth of a centimetre long. They weaken the plants by sucking sap from the leaves and stems. The insect injects a toxin into the plant, and in severe cases the leaves curl upward and turn yellow, finally becoming brown and brittle. This injury is commonly known as hopperburn. Hoppers are controlled by spraying DDT, Rogor or malathion.

Cut Worms—These insects damage young seedlings by cutting them at the base near the soil. The control measures are mixing 5% DDT dust in the soil at the rate of 25 kg per hectare before sowing or spraying 0.25% DDT at the rate of 1250 litres per hectare around the base of the plants.

Other insects which may be serious are the Colorado beetle, tuber moth, epilachna beetle, mites and wireworms. These can be controlled by timely spray of DDT, parathion or malathion.

Diseases and Their Control

Potatoes are attacked by a number of diseases. Some of the important ones are mentioned on the following pages:

Late Blight—This is the most serious fungal disease of the potato and is caused by *Phytophthora infestans*. The symptoms are brown to black, fast-spreading leaf spots, drying of leaves and stems and white mildew on the underside of leaves. Another easy method of detection is the rotten odour in the diseased tissue. Cool, moist conditions are congenial to this disease, but symptoms are visible when it is warm. The fungus spreads rapidly and lives in the diseased tubers. The control measures are spraying with a fungicide like Dithane M-45 @ 2kg/ha as soon as the plants are a few inches high until harvest. The interval may be 6 to 10 days or more according to weather conditions and use of disease-free seed.

Early Blight—This is not as serious as late blight and is caused by *Alternaria solani*. The main symptom is the presence of dead spots with concentric rings on leaves, but there is no wilting. The control measures are the same as in the case of late blight.

Common Scab—The affected tubers have rough corky lesions which are caused by a fungus, *Streptomyces scabies*. The organism lives in soil for a number of years and is not active at a pH range below 5.4 or above 7. In most areas scab is controlled by maintaining the soil reaction at pH 4.8 to 5.2. This disease is also checked by seed treatment with formaldehyde 0.5% Agallol-3 for 30 minutes or hot corrosive sublimate, if the disease organism is not already present in the soil. There are varieties available which are resistant to scab.

Verticillium Wilt—This is another fungal disease caused by Verticillium albo-atrum which is not serious in India. Wilting and discoloration of vascular tissues are the symptoms. It does not cause any rot of the tissue. The eyes of the tubers of the infected plants may be pink. As the disease is transmitted through the soil, it is difficult to control it. Use of disease-free seeds, resistant varieties and long rotations are recommended.

Charcoal Rot—It is one of the most serious storage diseases of fungal origin and is caused by *Macrophomina phaseoli*. The control measure is surface disinfection with some mercurial fungicide. The organism can survive in cold storage and resume its activity vigorously in the post-cold storage period. Resistant varieties are in the process of being bred.

Blackleg and Soft Rot—These are the two most important bacterial diseases of the potato. In case of blackleg, caused by *Erwina atroseptica*, the plants are stunted, the leaves turn yellow and are tightly rolled. The base of stem develops brown or black rotten areas. The disease when it reaches the tubers causes darkened areas both inside and outside. In storage an interior soft rot may develop. The plants attacked with ring rot show wilting and yellowing of leaves and a lemon yellow to light brown discoloration in the vascular rings of the tubers. This disease is caused by *Corynebacterium sepedomicum*. Both the diseases are carried through seed. So seeds should be completely disease-free. Long crop rotation should be practised.

Wart Disease—Black wart caused by *Synchytrium endobioticum* (Schito.) Perc. has been reported from Darjeeling and continues to be endemic to that area. Buds on stems, stolons, and tubers are the centres from where abnormal growth activity starts and leads to the development of warts. The warts vary in size with spherical outgrowth. Early growth is green or greenish-white in colour and later they become darker in colour, sometimes black. There is no known cheap control measure. Once the soil is infested, it is difficult to control the fungal organism except through soil sterilization by steam, mercuric chloride, copper sulphate or 5% formalin. Strict quarantine by preventing the entry of diseased material into healthy areas should be practised. There are some resistant varieties like Kufri Jyoti, Kufri Sherpa and Pimpernal.

Virus Disease—Diseases caused by virus are most destructive and difficult to control. The most important virus diseases in India are mosaic—latent and mild—rugose and leaf roll.

Latent Mosaic—It is caused by virus X and S. It is usually transmitted mechanically by the contact of diseased plants with healthy plants, or through knives and implements. There are a large number of strains some of which are very virulent.

Mild Mosaic—It is caused by virus 'A' alone or in combination with virus 'X'. When only virus 'A' is present, light green rugose leaves are formed. There may be some dead spots on the foliage and distinct mottling and crinkling of leaves. The virus is transmitted by a number of species of aphids. Disease-free seeds and resistant varieties constitute the control measures.

Rugose or Vein-banding Mosaic—This is caused by virus 'Y' alone or in combination with virus 'X'. The affected plant remains stunted, the leaves are severely wrinkled and sometimes mottled. Necrotic streaks may be present over the leaves and stems. The petioles and leaves become brittle and the plants ultimately die.

Leaf Roll—This virus often causes serious loss in potato-growing areas. The leaves of the infected plants become cupped, rolled upwards, leathery-textured and light green coloured. It is transmitted by the green pea aphid. Use of certified disease-free seed and control of the insect vectors are the possible measures of control of this disease.

Bacterial Brown Rot or Wilt—The disease is common mostly in tropical and sub-tropical areas. In India the disease has been reported from Bengal, Bihar, U.P. and in areas where potato is cultivated in rainy season. It is very often associated with root-knot nematodes affecting the crop. The causal organism is *Pseudomonas solanacearum*. The symptoms are wilting, stunting and yellowing of the foliage followed by collapse of the plant. There is browning of the xylem in the vascular bundles. The skin of the infected tubers is often discoloured. This disease also affects tomato, brinjal and chilli. The pathogen is soil-borne. Tuber transmission also occurs. The control measures are three year crop rotation with maize, soybean, etc. and use of disease-free seeds. Soil treatment with chemicals like chloropicrin and sulphur—lime is effective but too expensive. The best method of control is through suitable resistant varieties.

Soft-rot—The disease is caused by *Erwinia carotovora*. It affects the tubers in the field, during transit and storage. The symptom is softening of tissues. In advanced stage, it may be accompanied by watery ooze and unpleasant smell from the rotting tuber. The most effective control measure is to separate the diseased tubers from healthy tubers before storing. Seed tubers may be treated with 0.5% solution of Agallol-3/Aretan-6/Emisan-6 before storage for 30 minutes.

Mycoplasmal Diseases

Purple-top Roll—The growth of the shoot is retarded in affected plants. The young leaf rolls upwards but it does not become leathery or brittle as in the case of leaf roll. In cool weather these leaves develop purple to pink colour. The pathogen is transmitted by leaf hoppers *Alebrodes spp*. Tubers on the affected plants remain small and aggregate around the main stem.

Marginal Flavescence—It is prevalent in north-western hills. The affected plants, develop intense chlorosis on the top leaves. The disease badly affects the tuber production and the tubers often develop hairy sprouts.

Witch's Broom—The disease is prevalent in the Deccan Plateau. The plant growth is suppressed after infection and produce spreading type numerous filamentous, colourless to hyaline stems bearing small, simple leaves and aerial tubers. These plants either do not produce tubers or only very small sized tubers are produced mostly with hairy sprouts.

Potato Phyllody—This disease is also prevalent in the Deccan Plateau. The effected plants develop fasciated stem, wavy wings and margins, hairy and chlorotic leaves. The pathogen is transmitted through tubers.

There are number of physiological disorders. Some of them are black heart, hollow heart, greening and freezing injury.

Black Heart—It is caused by suboxidation. Whenever potatoes are stored in piles so that air cannot get to the centre of the pile, this condition is likely to result. The higher the temperature, the more favourable the condition for the production of black heart. Even with the temperature at 3°C to 4°C it is not safe to store potatoes so that the centre of the pile is more than one and a half metres from the surface.

Hollow Heart—This condition is brought about by a very rapid growth. Closer spacing and removal of foliage when hollow heart starts are the control measures. These practices, however, reduce the yield.

Greening—This is caused by the exposure of the tubers to direct sunlight. The green pigment is caused by 'solanin' which is slightly poisonous. Proper earthing-up is done to prevent this.

Freezing Injury—Slightly frozen tubers may be identified by the discoloration of the fibro-vascular tissue. Entirely frozen tubers on thawing present a cheese-like appearance and later the tissue breaks down into slimy, watery masses. Potatoes under usual conditions start to freeze at—1.5°C.

Root-knot Nematodes—It is a serious pest of the potato. Golden nematode which is most destructive has been detected for the first time in India in the Nilgiris. Quarantine for seed export has been imposed to check its spread. Soil treatment with nematicides like DD or Nemagon is recommended. Recently some resistant varieties have been detected.

Production of Certified Seeds

This is being done by the Central Potato Research Institute, Simla. The main aims are production, maintenance and multiplication of pure, disease-free foundation seed of potato varieties under commercial production. The work is carried out at Kufri, Simla and Mukhteswar. Nucleus seeds are maintained at Kufri and Simla and foundation seeds are produced at Mukhteswar. Hill areas can, however, supply only 30 per cent of the total requirement of seed potato of the whole country. The following suggestions are made to produce healthy seeds in the plains of India:

(i) For seed purposes, use only certified disease-free seed.
(ii) Plant the crop in autumn as early as possible, preferably by the end of September. The planting should never be delayed beyond the first week of October.
(iii) Sow at close spacing and on a not-too-rich soil.
(iv) During the growing season, at least two inspections should be made to rogue out any diseased or off-type plants.
(v) When the crop has tuberised well by the middle of December, restrict irrigation and later withhold it

completely. Haulms should wilt before the aphids build up population by the end of January. If the crop is still green, kill the haulms with a 2 per cent solution of copper sulphate or cut green haulms.

(vi) Leave the crop underground till the end of February.

(vii) In early to mid-March harvest, sort and store separately in cold storage as seed for subsequent autumn planting.

CHAPTER V

Solanaceous Fruits

THIS GROUP includes three very important vegetables, tomato *(Lycopersicon esculentum)*, brinjal or egg-plant *(Solanum melongena)* and chilli or pepper (*Capsicum annuum*). The last crop has three commercially cultivated types: one which is consumed even as green but more so after drying, some are also pickled. The next type, the bell pepper type, is consumed green. The third type is small and pungent (*Capsicum frutescens*) and is also known as bird pepper. This is consumed more as a condiment after drying and powdering the ripe fruits. The fourth fruit, husk tomato (*Physalis pubescens*) is not commercially grown. The plants are vigorous, semi-prostrate and resemble cape gooseberry. The fruits when immature are green and turn yellow on ripening. The fruits are enclosed in a husk. The fruits are fried, baked, stewed, cooked with meat, made into soup, dessert, sauce, marmalade and salad. All the above four vegetables belong to the family Solanaceae and their cultural operations have many things in common.

TOMATO

(*Lycopersicon esculentum* Mill)

Hindi: *Tamatar; Vilayti baingaṅ*

The tomato is one of the most important "protective foods" both because of its special nutritive value and also because of its widespread production. It is the world's largest vegetable crop after potato and sweet potato, but it tops the list of canned vegetables. Tomatoes are used for soup, salad, pickles, ketchup, puree, sauces and in many other ways. Tomatoes have been used as food by the inhabitants of Central and South America since pre-historic times. It has originated in Peruvian and Mexican regions. It was introduced into Europe by the Spanish explorers in the early sixteenth century. European migrants later on introduced it to the U.S.A. and Canada. It was perhaps introduced into India by the Portuguese though there is no definite record of when and how it came to India. According to an estimate of FAO, an area of over 80,000 ha. was under tomato in 1978, with an annual production of nearly 740,000 tonnes.

Nutritive Value

The outstanding value of the tomato as a source of special nutrients needed in the diet is indicated by its nutritive value:

(per 100 g of edible portion)

Moisture	93.1	g	Vitamin A	320	I.U.
Protein	1.9	"	Thiamine	0.07	mg
Fat	0.1	"	Riboflavin	0.01	"
Minerals	0.6	"	Nicotinic acid	0.4	"
Fibre	0.7	"	Vitamin C	31	"
Other carbohydrates	3.6	"	Calories	23	"
Calcium	20	mg	Sodium	45.8	mg
Magnesium	15	"	Potassium	114	"
Oxalic acid	2	"	Copper	0.19	"
Phosphorus	36	"	Sulphur	24	"
Iron	1.8	"	Chlorine	38	"

The nutritive value varies in different varieties and also depends upon the environment in which it is grown.

Taxonomy and Varieties

The tomato belongs to the family Solanaceae and to the genus *Lycopersicon*. There are several species but only two are edible: *esculentum,* the cultivated tomato and ***pimpinellifolium***, small fruited tomato.

Many varieties of the tomato are grown all over the country. They can be grouped as determinate, indeterminate and intermediate. Determinate types are usually early. Some of the promising and recommended varieties of I.A.R.I. are **Pusa Early Dwarf, Pusa Ruby, Sioux, Marglobe, Best of All, La Bonita, Pusa 120, Pusa Sheetal, Pusa Gaurav, Italian Red Pear** and **Roma**. The last two varieties are pear shaped and stand long transport. Varieties recommended by certain States are:

U.P.—**T1, Ponderosa, Pritchard, Kalianpur Angurlata.**

Bihar—**Marglobe, Oxheart.**

Punjab—**Devlin's Choice, Red Cloud, Sl. 12, Keckruth, Keckruth Ageti, Punjab Tropic, Punjab Chhohara, Punjab Kesri,**

Haryana—H.S. 101, H.S. 102.

Tamil Nadu--Marutham

I.I.H.R.—**Arka Saurabh, Arka Vikas**

Climate and Soil

The tomato is a warm season crop. The plants cannot stand severe frost. The crop does well under an average monthly temperature of 21° C to 23° C but commercially it may be grown at temperatures ranging from 18° C to 27° C. Temperature and light intensity affect the fruit-set, pigmentation and nutritive value of the fruit.

The best soil for tomato is rich loam, with a little sand in the upper layer, and a good clay in the sub-soil. Good texture of the soil is of primary importance. Poor and medium quality lands produce good early crops if managed properly. If the soil is acidic, liming will be beneficial. However, this is not recommended unless the soil pH is 5.0 or lower. Tomatoes do best in a soil that has a soil reaction from pH 6.0 to 7.0.

Sowing Time

Seeds are sown in well-prepared nursery beds. In northern India two sowings are done. The autumn-winter crop is raised by sowing the seeds in June-July and for the spring-summer crop the seeds are sown in November. In parts of the country where danger owing to frost does not exist and where summer sets in early only one sowing during July-August is done. Two to three sowings can be done in regions with mild climate. In the hills the seed is sown in March-April.

Seed Rate

There are about 300 seeds to a gram and about 400 to 500 grams of seed are needed for one hectare.

Transplanting

The plants must be hardened as they approach planting-out time.

This is done by exposing the seedlings to open weather or by withholding irrigation now and then. A suitable tomato plant for transplanting is 7.5 cm to 10 cm in height and has a good sturdy stem. The spacing recommended for the autumn-winter crop is 75 x 60 cm and for the spring-summer crop 75 x 45 cm. The use of starter solution (a dilute solution of nitrogen, phosphorus and potash) at the time of transplanting has been reported beneficial

Manures and Fertilizers

Tomatoes require large quantities of readily available plant foods. The use of manures and commercial fertilizers varies with locality and soil. The application of large quantities of stable manure is liable to produce excessive vine growth. A yield of 16,000 kg of tomatoes removes 50 kg of nitrogen, 16 kg of phosphate and 65 kg of potash from soil. For a good yield 20 to 25 tonnes per hectare of well-rotten farmyard manure should be incorporated in the soil at the time of preparation. About 550 kg of single superphosphate per hectare may be applied in the root zone at the time of transplanting. This may be supplemented by 275 kg of ammonium sulphate and 175 kg of potassium sulphate. A top dressing of 275 kg of ammonium sulphate is beneficial after a month. If farmyard manure is not available, double the quantity of ammonium sulphate is required. Foliar application of nitrogen in the form of urea and phosphorus in the form of triple superphosphate substantially increases the yield of tomato. Foliar application of 35 kg of nitrogen and 45 kg phosphate per hectare in four or five sprays is recommended. Concentrations higher than one per cent may scorch the leaves.

Irrigation

Tomatoes need very careful irrigation, that is just sufficient water at the right time. It has been observed that the water-table of an area plays an important part in meeting the moisture needs of this crop. It is necessary to maintain an even moisture supply; overwatering is as harmful as insufficient irrigation. Young plants should be watered only when they apparently need it. Therefore, staked crops will need water every five to seven days and ground crops every ten days. A period of drought followed by a sudden heavy watering during the fruiting period may cause cracking of fruits.

Cultivation

Tomato plants require frequent shallow cultivation, especially during their first four weeks in the field. The surface soil is loosened by hand-hoeing as soon as it is dry enough after every irrigation or shower. All weeds should also be removed in this process. Mulching with straw, black polythene and many other materials has been found beneficial in moisture conservation, in controlling weeds and some diseases and in bettering the quality and yield.

Pruning and Training

Often for early market the tomato plants are pruned to a single stem and tied to a stake. Various methods of pruning and training are followed. Single stem training is most common. In this system all the young shoots that grow in the axil of the leaves are pinched off. Though some advantages are claimed for pruning and training, considering the expenses involved, this system is not followed by most commercial tomato growers.

Fruit-Set

In early spring and autumn, the failure of fruit-set in tomato is a common problem. In early spring it is due to the prevailing low temperature and in early autumn it is due to high temperature. When night temperatures are below 13°C the pollination and fertilization processes are impaired. Day temperatures exceeding 38°C may adversely affect fruit-set. When poor setting is due to failure of pollination or fertilization,. use of plant regulators improves fruit-set. Flower cluster or whole plant sprays are very effective. The plant regulators which have been found effective are para-chlorophenoxyacetic acid at 15 to 20 ppm, 2,4-dichlorophenoxyacetic acid at 1 to 5 ppm. A mixture of 1 per cent urea and 2,4-D at 1 to 2 ppm as whole plant spray when the first few flower clusters appear has been found very effective and economical. Even soaking the seeds in solutions of plant regulators for 24 hours prior to sowing has been found beneficial. Effective concentrations may vary with the environment and variety. There are varieties like **Hotset** and **Coldset** which set fruit at higher and lower temperatures.

Hybrid Tomato

High, early and total yield, uniform fruiting, and resistance to adverse environmental conditions are some of the advantages of using F_1 hybrid seeds. The main drawback is the high cost of production of these seeds. The use of male-sterile lines can decrease this cost. There are a number of combinations which give good yields. A combination of Pusa Ruby and Best of All is preferred as the F_1. It not only yields 50 per cent more than Pusa Ruby but its fruit quality is also very attractive. Even the F_2 generation of this combination gives a 15 to 20 per cent higher yield and the segregating lines are all marketable. The other combination recommended is Pusa 120 × Pusa Ruby. The F_1 not only gives a high yield of attractive fruits but is also resistant to root-knot nematodes.

Harvesting

The stage of maturity at which tomatoes are picked depends on the purpose for which they are grown and the distance over which they are to be transported. Immature green, mature green, turning, half-ripe or pink and ripe or red ripe are some of the recognised stages. For shipping, firm mature green fruits are picked. Tomatoes for canning are picked when they are fully ripe. The yield varies from 16,000 to 24,000 kg per hectare.

Grading

The grading of tomatoes for the market is being followed to some extent for specialised city markets. The Indian Standards Institution has specified four grades: Super A, Super, Fancy and Commercial.

Storage

The best storage temperature is from 12°C to 15°C. When stored at freezing-point, the fruits show low temperature injury. Mature green fruits can be kept for as long as 30 days at 10°C to 15°C. Ripe tomatoes can be kept for 10 days at 4.5°C. The recommended relative humidity is 85-90 per cent.

Seed Production

The tomato is mainly a self-pollinated crop but a certain percentage of cross-pollination has also been recorded. The percentage of out-crossing may depend on the variety and environment. It is, therefore, safe to keep 50-100 metres of isolation between two varieties for production of seed. The seed along with the pulp is left in a wooden container to ferment for 2 to 3 days before extraction. The seed is then extracted by vigorous stirring and washing. The acid or alkali method is now used to avoid handling the fermented material. The acid method is more common. 100 ml of commercial hydrochloric acid is thoroughly mixed and stirred for every 11 kg of pulp and left for about 30 minutes. The pulp is then again stirred and the seed washed. The seed yield varies with the variety. The average is about 100 to 120 kg per hectare.

Diseases

The tomato is prone to a number of diseases. The causes may be fungi, bacteria, viruses, root-knot nematodes or abnormal environments. Some of the important diseases and their control measures are described on the following pages.

Damping Off— The seedlings are mostly attacked in the nursery-bed at the ground level and as a result they topple over. The causal organisms may be *Pythium* spp. or *Rhizoctonia* spp. or *Phytophthora* spp.

The control measures are sterilization of the nursery soil either by steam, formalin or some strong copper fungicide. The seed should also be treated before sowing with some copper compound like ceresan.

Fusarium Wilt: The lower leaves become yellow and the petioles droop. Subsequently the affected plants wilt and die. The disease is caused by the fungus *Fusarium oxysporum f. lycopersici* which persists almost indefinitely in the soil. Control measures are: use of seeds from healthy plants, crop rotation with crops not affected by the fungus and using resistant varieties like Marglobe, Rutgers, Pritchard, Manalucie, etc.

Early Blight: The disease is caused by the fungus *Alternaria solani.* The disease affects the foliage and causes brown spots on immature fruits. In severe cases fruits drop off and the whole plant dries up. Seed from infected plants should not be used. Seed treatment with a copper compound and intermittent spray with

Bordeaux mixture may help to control the disease.

Late Blight: The disease is caused by the *Phytophthora* species and has become very destructive, especially in some hill states. The disease attacks the leaves and stems as well as the fruits. The rotten portions of the fruit remain firm with a dark blotchy, brownish green colour which does not turn pink, while the unaffected parts of the tomato ripen. This disease can be controlled by prompt and thorough spray of Bordeaux mixture (4-4-50). Dusting with copper lime is helpful where spraying is impracticable.

Leaf Mould: The disease is caused by the fungus *Cladosporium fulvum*. Yellowish green blotches in the upper surface of the leaves accompanied by grey or greenish brown mouldy spots are the main symptoms. The disease is more common in humid warm regions. Vetomold is reported to be a resistant variety.

Bacterial Canker: The disease is caused by *Corynebacterium* spp. The stems when split open show light brown or dark streaks. Yellow to brown streaks also are seen inside the affected fruits. The disease is carried through seed as well as through soil and compost. Infected plants should be carefully collected and burnt. Long rotation with crops not affected by the disease should be followed.

Bacterial Wilt: is a serious disease of tomato in areas having tropical humid climate. In India it is severe in Kerala, Tamil Nadu, Karnataka and parts of West Bengal, Orissa, Bihar, Andhra Pradesh and Maharashtra. The causal organism is *Pseudomonas solanacearum*. The typical symptoms are wilting, stunting and yellowing of the foliage followed by collapse of the entire plant. When the infected stems are cut across and squeezed, grayish white bacterial ooze comes out of the vascular ring. The pathogen is soil-borne and can survive in soil for long. The infection enters through injured roots or stem. Root-knot nematodes help in penetration. Proper rotation with cereals sometimes helps. The best method of control is by use of resistant varieties. The Asian Vegetables Research and Development Centre, Taiwan, has evolved some lines which are promising.

Leaf Curl: This is the most serious virus disease of tomato in India. This is more severe in the rainy and the autumn seasons. The symptoms are smalling, puckering and curling of the leaves and stunted growth of the plant. The disease is spread in nature by an insect known as white fly. Roguing the affected plants when the attack is severe is not very effective owing to many alternate host plants. Weekly spraying in the early stages of crop with some insecticide to keep down the population of the insect vector reduces the incidence of the disease. A late sown autumn crop suffers less than an early sown crop. There is no resistant variety yet developed. Dipping roots of the seedlings for about an hour in a solution of CCC (Cycocel) at 500 ppm before transplanting and subsequently spraying the crop twice with the same solution in the preflowering stage reduces the incidence of the disease.

Mosaic: This disease commonly known as tobacco mosaic virus is characterised by the appearance of chlorotic areas on the leaves. Such areas turn yellow and these are interspersed with green areas. The virus is highly infectious. The only control measure is the precaution taken in handling diseased and healthy plants.

Fern Leaf: The leaves of the affected plants often become narrow and thread-like. In extreme cases only the mid-rib is present. This is caused by cucumber mosaic virus and aphids are the insect vectors. Roguing out the diseased plants and spraying Malathion to control the aphids help in reducing the spread of disease.

Root-knot Nematodes: They are small microscopic worms that infect the roots. There are a number of genera which affect tomato. The genus *Meloidogyne* is the most common. They penetrate the roots and cause irregular swellings. Stunting of plants, yellowish to bluish discoloration of leaves and early death are the symptoms of the nematode affected plants. The nematodes can considerably decrease the yield. The control measures are (1) soil fumigation with nematicides like DD or Nemagon; (2) rotation with resistant crops like sorghum, corn, onion, or *Tagetes;* and (3) using resistant varieties like Pusa 120 and Nematex.

Tomato suffers from a number of physiological disorders. The most common are 'puff', 'catface', sunscalding and hail injury. The fruits affected by 'puff' are light in weight and when cut open large cavities are noticed. The fruits are somewhat angular in shape with flattened sides and a hollow core. The fruits with 'catface' are characterised by the distortion of the blossom end of the fruit. Such fruits have ridges, furrows, indentations and blotches. The cause of 'puff' and 'catface' is not known so far, although there is some evidence that they are inherited because some varieties get more of these defects than others. The fruits and leaves of tomato plants may be damaged by intense sunlight. The exposed surface of the fruit becomes yellow, or develops brown, burned areas. Sunscalding may be avoided by not staking the plants, avoiding turning over the plants at the time of picking and growing varieties with abundant foliage.

The fruits hit by hails form hail spots which are small to medium, slightly sunken circular areas turning from white to yellowish green. The underlying tissue becomes spongy in texture and whitish in colour.

Insect Pests

The tomato is attacked by a number of insect pests. Some important ones with their possible control measures are listed below:

Tomato Fruit Worm: This is a serious pest of the tomato. Immediately after hatching, the caterpillar crawls over the leaves and feeds on the vegetative parts. It eventually finds its way to the fruits into which it cuts holes and burrows. The following control measures are suggested: (1) collection of the attacked fruits and their destruction, (2) spraying with 0.1 per cent DDT at fortnightly intervals in the early stage of development of fruit, (3) proper rotation of crops, and (4) hot weather cultivation.

Epilachna Beetle: Both larvae and adults feed on the leaves. The feeding is irregular and gives the plants a characteristic lace-like appearance.

The control measures are: (1) if possible, it is advisable to destroy the larvae and the eggs by hand-picking, (2) five per cent DDT dust at 20 to 25 kg per hectare or 0.1 per cent DDT spray at 600 to 1200 litres per hectare should be applied: All mature fruits should be picked before spraying or the fruits if used after ten days after spraying should be thoroughly washed.

In addition to these jassids, red mites become a serious threat to the crop wherever tomatoes are grown in warm humid conditions.

BRINJAL (Egg plant)

(Solanum melongena L.)

Hindi: *Baingan*

The Brinjal is a native of India. It has been in cultivation in India since ancient times. It is one of the most common vegetables grown throughout the country. There are no reliable statistics available regarding the area under brinjal in India. The approximate area may be around 50,000 hectares. The actual area at present must be many times more.

Nutritive Value

The common belief that the food value of brinjal is low is not correct, which is evident from the table given below.

The nutritive value varies in different varieties.

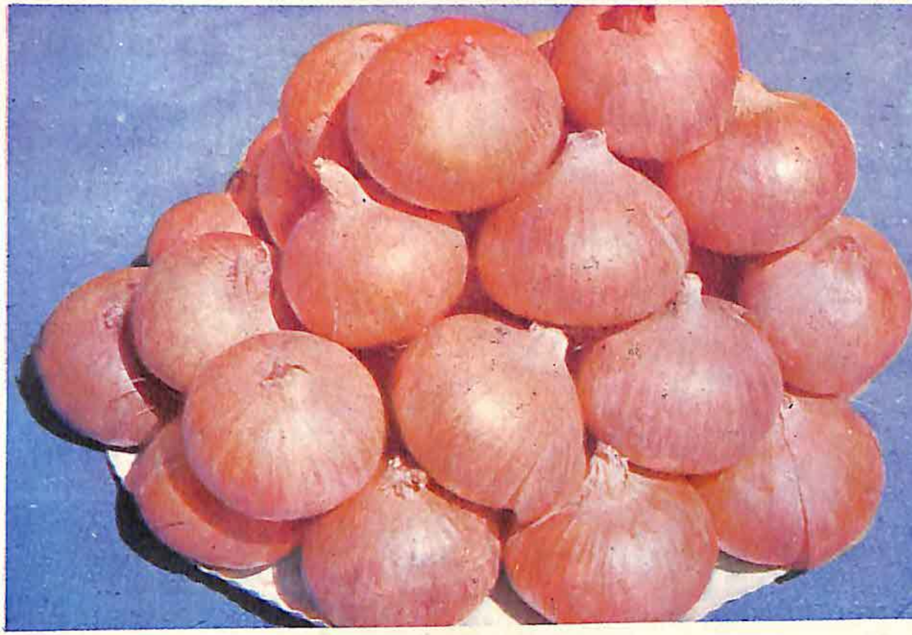
The brinjal has got Ayurvedic medicinal properties and white brinjal is said to be good for diabetic patients.

(per 100 g of edible portion)

Moisture	92.7 g	Iron	0.9 mg
Protein	1.4 g	Sodium	3.0 mg
Fat	0.3 g	Potassium	200.0 mg
Minerals	0.3 g	Copper	0.17 mg
Fibre	1.3 g	Sulphur	44 mg
Other carbohydrates	4.0 g	Chlorine	52 mg
Calories	24	Vitamin A	124 I.U.
Calcium	18 mg	Thiamine	0.04 mg
Magnesium	16 mg	Riboflavin	0.11 mg
Oxalic acid	18 mg	Nicotinic acid	0.9 mg
Phosphorus	47 mg	Vitamin C	12.0 mg

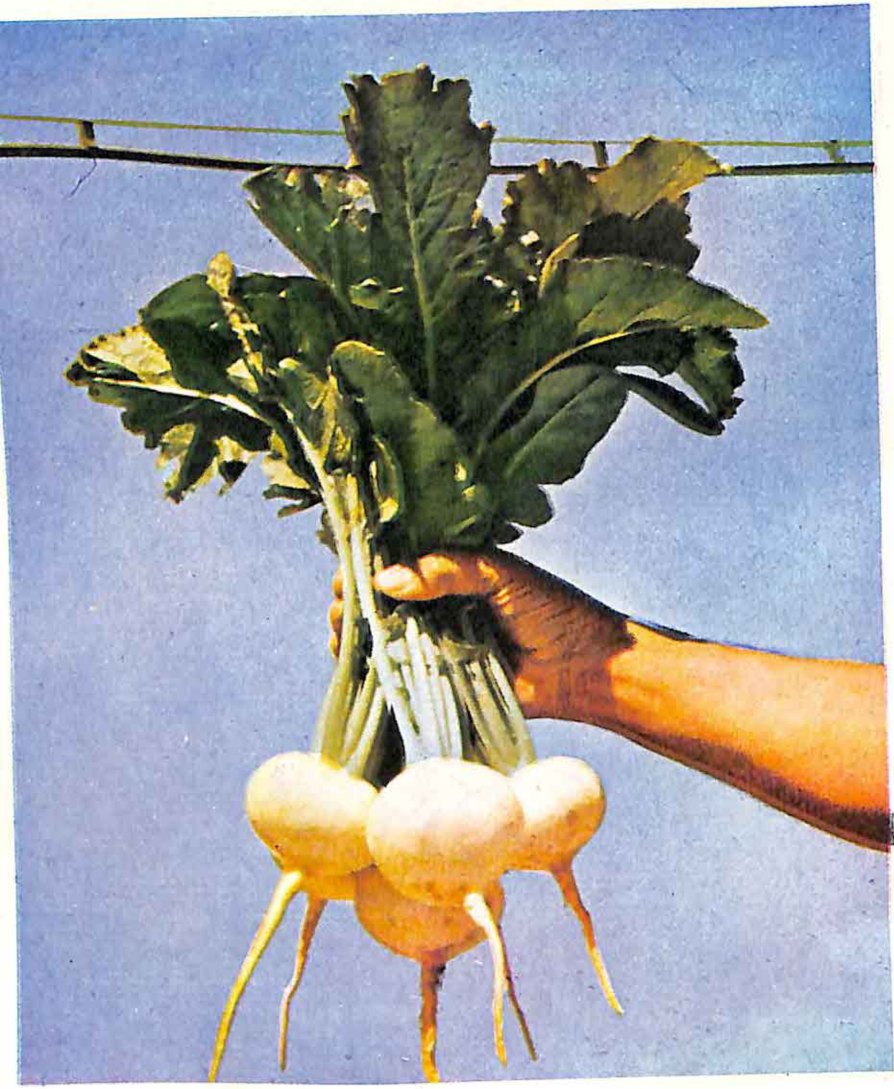
Taxonomy and Varieties

The brinjal belongs to the family Solanaceae and to the genus *Solanum*. It belongs to the species *melongena*. Many varieties are grown throughout India. Varieties differ in shape and colour of fruits and also in the growth habit of the plant. The round or egg-shaped varieties are grouped under var. *esculentum*. The long, slender types are put under var. *serpentinum* and the dwarf early ones under var. *depressum*. The recommended varieties of I.A.R.I. are **Pusa Purple Long, Pusa Purple Round, Pusa Purple**



Onion *Pusa Red*

Vegetables on display.



Turnip *Pusa Sweti*

Cluster, **Pusa Kranti, Pusa Bhairab.** Varieties recommended by other States and Institutes are:

U.P.—**Black Beauty, Banaras Giant, T_1, T_2 and T_4**
Bihar—**Mukatakeshi, ST_1, ST_2**
Punjab—**Black Beauty, Punjab Chamkila Jamuni Gol** and **Punjab Bahar**
Tamil Nadu—**Wynad Giant, Gudyattam**
Maharashtra—**Surti Gota, Manjri Gota, Vaishali**
I.I.H.R.—**Arka Sheel, Arka Kusumakar, Arka Sirish, Arka Navneet**

Climate and Soil

Brinjal requires a long warm growing season. The plant is killed by severe frost. A long spell of chilly frostless weather may also damage the crop. The late varieties withstand mild frost. A daily mean temperature of 13°C to 21°C is most favourable for its successful production. A well-drained and fertile soil is desirable for growing brinjal. It is a hardy plant and can be grown on different kinds of soil but does best on silt loams or clay loams. If the soil is not naturally fertile, manures and fertilizers should be added. For an early crop sandy or sandy loam soil is preferred.

Sowing of Seeds

The seeds are sown in raised nursery beds 6 to 12 mm deep in rows 5 cm apart. The bottom few centimetres of the nursery bed should have small chips and sand to allow a good drainage. The top soil should be mixed properly with farmyard manure or compost and leaf mould. A small quantity of superphosphate may be used. Immediately after sowing, the nursery-bed is covered with straw or other mulching material till the seed germinates. There are two, sometimes three, main seasons for sowing brinjal:

1. *Autumn-winter crop:* Seed is sown in June and seedlings transplanted in July.
2. *Spring-summer crop:* Seed is sown in early November and the seedlings transplanted during January and early February. The nursery-bed should be protected from frost.
3. *Rainy season crop:* Seed is sown in March and the seedlings transplanted in April.

Sometimes to get brinjals throughout the year, another sowing is done in September or early October and the seedlings are transplanted in November. Special care is to be taken to protect this crop from frost.

In the hills the seed is sown in April and the seedlings are transplanted in May.

Seed Rate

There are about 250 seeds to a gram. About 375 to 500 g of seed are needed for one hectare.

Transplanting

The seedlings are transplanted when four to six weeks old, depending on the season, in a well-prepared field. The planting distances depend on soil fertility, season and variety. Usually, for the bushy, non-spreading type, the spacing should be 50 to 60 cm from row to row as well as from plant to plant. For spreading varieties, the row to row distance should be 75 to 90 cm and that for plant to plant 60 to 70 cm.

Manures and Fertilizers

The preparation of land depends on the type of soil and the previous crop. Proper drainage is essential for growing brinjals. Organic manures are mixed with the soil at the time of its preparation. Brinjal, being a long-standing crop, needs a good dose of manure. Where it is available, 20 to 25 tonnes of farmyard manure per hectare should be incorporated in the soil at the time of preparation. This is to be supplemented with about 100 kg of nitrogen and 50 kg each of phosphate and potash. Half the dose of nitrogen and full doses of phosphate and potash should be added before transplanting and the rest of the nitrogen should be added in one or two instalments as a top-dressing. A ratoon crop should be fertilized independently after harvest of the first crop.

Interculture and Irrigation

Only shallow cultivation to control weeds or to work in top-dressings of fertilizers is necessary. Care must be taken to see that there is no setback to the crop owing to either weeds or insufficient water. Hence, timely irrigation is necessary. About 100 to 110 cm of irrigation are required for a successful brinjal crop.

Fruit-set

Four types of flowers have been described under brinjal. This grouping is made on the basis of the length of the style. The types are long-styled, medium-styled, pseudo short-styled and true short-styled. Only long and medium-styled flowers, marked by a swollen ovary at the base, bear fruits. The other two types have rudimentary ovaries which do not develop into fruits.

Work has shown that the fruit-set can be increased with plant regulators. The chemicals which have been found effective are para-chlorophenoxyacetic acid and 2,4, dichlorophenoxyacetic acid (2,4-D) and naphthaleneacetic acid. The most practical methods are seed treatment and whole plant spray. The cheapest and most easily available chemical is 2,4-D. The seed can be soaked for 24 hours in a solution of 2,4-D at 4 to 5 ppm before sowing or spraying the whole plant with 2,4-D solution at 2 ppm when the first few flower clusters appear. These treatments give about 50 per cent earlier and higher fruit-set.

Hybrid Vigour

Hybrid vigour has been reported in brinjal by many workers in India and abroad. The first-generation hybrids not only give earlier and higher yields, but the hybrids are also more resistant to adverse weather conditions and pests and diseases. A well-chosen varietal combination can give an 80 to 100 per cent higher yield than the better parent. The cost of hybrid seed production of brinjal is not high as compared to other vegetables and this can be further reduced by the use of male-sterile lines. The best varietal combination selected at the I.A.R.I. is a cross of Pusa Purple Long and Hyderpur known as **Pusa Anmol. Arka Navneet** is the recommended F_1 hybrid of I.I.H.R.

Harvesting and Yield

The fruit is harvested when it attains a good size and colour. The surface of the fruit should not lose its bright and glossy appearance. The fruits are edible from the time they are quarter-grown, until they are near-ripe. When full ripe, the fruits become greenish-yellow or bronze; their flesh turns dry and tough. Harvesting is done by cutting the fruit from the stem. A short piece of the stalk is left attached to the fruit. The average yield varies from 20,000 to 25,000 kg per hectare.

Grading

The Indian Standards Institution has recommended three grades of brinjal, viz., Super, Fancy and Commercial.

Storage and Shipping

The harvested fruits can be kept for seven to ten days in good condition at 10°C to 13°C and 85-90 per cent relative humidity. The fruits should be handled with care and wrapped in paper before they are packed for shipping. They are packed loose in bulk or packed in containers for trading and transport. In the latter case, the brinjals should be packed in loosely-woven gunny bags or net bags or wooden crates.

Seed Production

Brinjal is a self-pollinated crop, but there is a good deal of natural crossing through insects. The amount of cross-pollination varies with variety and season. It is, therefore, advisable to keep at least 50 to 100 metres of isolation distance between any two varieties grown for seed production. The fruits are harvested when fully ripe. The outer covering is peeled off and the flesh with the seed is cut into thin slices. These are then softened by soaking till the seed separated from the pulp to which water is added gradually. If the material is allowed in this condition to stand overnight, the separation of seed from the pulp becomes easier. After separation, the seed should be dipped into water. Those which float should be rejected. The seed should then be dried in partial shade before storing. The yield of seed varies with variety, the average being 100 to 120 kg per hectare.

Diseases

Brinjal is attacked by a number of diseases. Only some important diseases are mentioned with their possible control measures.

Damping Off—The disease is caused by *Phytophthora* or *Pythium* species and occurs in the nursery stage. The fungi live in the soil. The attacked seedlings dry up at ground level and topple over. The control measures are sterilization of the nursery soil and treating the seeds with some fungicide before sowing.

Phomopsis Blight: This is a serious disease of brinjal. It is caused by the fungus *Phomopsis vexans*. The fungus attacks all parts of the plant above ground. The symptoms are brown, circular or oblong spots on the fruits becoming irregular with age.

The following are the control measures:

1. use of seeds from disease-free plants;
2. seed treatment with some fungicide;
3. use of resistant varieties like **Florida Market** or **Pusa Bhairab**
4. long rotations;
5. weekly spraying of nursery and field with some fungicidal spray; and
6. hot water treatment of seeds at 50°C for 30 minutes.

Wilt: This is caused by *Fusarium, Ozonium* or *Verticillium* spp. The disease is characterised by yellowing of the foliage. The lower leaves turn yellow and then brown between the veins. If the stem is cut lengthwise, the vascular tissue inside is dark. Affected plants become stunted and may die eventually.

The control measures are:

1. use of resistant varieties;
2. long crop rotations; and
3. periodical spraying with some fungicide.

Sclerotinia Wilt: This disease is caused by *Sclerotinia* spp. Minute mustard-like structures adhere to the stem at ground level. These put out mycelia which enter the stem and choke the vessels. This is spread from one plant to the other by irrigation.

It is difficult to control the disease as the fungus persists in the soil. Long crop rotations with crops which are not affected by this disease and mixing some copper fungicide in the soil before planting the crop are recommended.

Bacterial Wilt: The same as described under tomato. Some cultivars like **Pusa Purple Cluster** and **Annamalai** have shown field resistance.

Mosaic: This is a virus disease. The control measures are roguing out the affected plant in the earlier stages, maintaining sanitary conditions and use of resistant varieties.

Little Leaf: This is a serious disease of brinjal caused by mycoplasma. The symptoms are numerous small leaves and deformation of flower parts. The disease is spread by a leaf-hopper belonging to the genus *Cestius*. Removal of the affected plants in the initial stages and spraying with some insecticide like Rogor or Malathion till fruit-set may help to check the spread of the disease. Root dip at the time of transplanting with 1000 ppm of tetracycline followed by three sprays, at weekly intervals of four to five weeks after transplanting checks the disease.

Root-knot Nematodes: The infected plants become stunted and the leaves show chlorotic symptoms. Some types cause nodule formation on the roots.

The control measures are:

1. rotation with crops resistant to root-knot nematodes, like marigold;
2. soil fumigation with some nematicides like DD or Nemagon; and
3. use of brinjal varieties resistant to nematodes.

Insect Pests

The brinjal crop is attacked by a number of insects. Some of the important ones are described below:

Epilachna Beetle: It causes serious damage to the foliage in the earlier stages of growth. The beetle is bronze to red, small and dome-shaped. The grub is light yellow and hairy. The adult eats up regular area of leaves. The control measures are: (1) in the initial stage of attack, the infested leaves with the insects should be picked and destroyed; (2) the plants should be dusted with 5 per cent BHC at the rate of about 20 kg per hectare or sprayed with 0.05 per cent of 50 per cent water dispersible or wattable powder of DDT at the rate of 1 to 2 kg per hectare, according to the size of the plant.

Shoot and Fruit Borer: This is the most serious pest of brinjal. In the initial stages it attacks the terminal shoots and bores inside. Later, it also bores into the young fruits as soon as they start setting. The control measures are: as soon as the insect is detected, the affected part should be clipped along with the insect and destroyed. Any fruit with holes should be picked and destroyed. A mixture of 20 per cent Lindane (11 ml) and 25 per cent DDT (9 ml) in 9 litres of water is then thoroughly sprayed on the crop. About 650 to 850 litres of this mixture are needed for one hectare. The procedure should be repeated in case of further infection. All fruits on the plant should be picked before spraying.

Red Mite: The small insects suck the sap from the leaves. In severe cases the whole plantation looks yellowish and cobwebs are seen on the leaves. Spraying with Aramite or dusting with sulphur controls the insects. Other insects attacking brinjal are aphids, and jassids, but these are not usually serious.

CHILLI

(*Capsicum annuum L.* and *Capsicum frutescens* L.)

Hindi : *Mirch*

Chilli is one of the most valuable crops of India. Different varieties are grown for vegetables, spices, condiments, sauces and pickles. The crop is grown practically all over India. Among the most important States only four, Andhra Pradesh, Maharashtra, Karnataka and Tamil Nadu account for three-fourths of the total area. The other States having large areas under chillies are Madhya Pradesh, the Punjab and Bihar. A small quantity of dry chilli is also exported. There is a good scope for increasing its exports by pushing up production.

The cultivated chillies are undoubtedly of American origin. They are known from pre-historic remains in Peru. They were widely cultivated in Central and South America, and were unknown in Europe prior to the discovery of America.

Chillies are rich in vitamins, especially in vitamins A and C. The analysis of green chilli shows the following composition:

(per 100 g of edible portion)

Moisture	85.7	g	Iron	1.2	mg
Protein	2.9	g	Sodium	6.5	mg
Fat	0.6	g	Potassium	217	mg
Minerals	1.0	g	Copper	1.55	mg
Fibre	6.8	g	Sulphur	34	mg
Other carbohydrates	3.0	g	Chlorine	15	mg
Calories	29		Vitamin A	292	I.U.
Calcium	30	mg	Thiamine	0.19	mg
Magnesium	24	mg	Riboflavin	0.39	mg
Oxalic acid	67	mg	Nicotinic acid	0.9	mg
Phosphorus	80	mg	Vitamin C	111	mg

The pungency in chillies is due to an alkaloid, capsaicin, which has good export possibilities.

Taxonomy and Varieties

The chilli belongs to the family Solanaceae and genus *Capsicum*. Only four species are under cultivation, out of which the cultivation of two; *C. pendulum* and *C. pubescens*, is restricted to South and Central America. The other two, *C. annuum* and *C. frutescens*, and commercially cultivated throughout the world. *C. annuum* is most common cultivated species and all green chillies in the market and most dry chillies belong to this group. Most of small highly pungent chillies belong to *C. frutescens*.

The varieties of chillies are broadly divided into two groups, long pungent types including pickling types and bell-shaped non-pungent, mild, thick-fleshed types. The mild types are used as vegetables and commonly known as "sweet peppers" or *Simla mirch*. The following are the important varieties of the long pungent types: **NP 46A, Pusa Jwala, Pusa Sadabahar G1, G2, G4, G5, Panth C-1, Arka Basant, Andhra Jyothi**

Among the sweet pepper group, the important varieties are **California Wonder, Yolo Wonder, Arka Mohini, Arka Gaurav** and **King of North.**

pushing up production.

The cultivated chillies are undoubtedly of American origin.

Climate and Soil

The chilli is a plant of tropical and sub-tropical regions requiring a warm humid climate. This crop can tolerate extremes of climate better than tomato and brinjal. It also cannot withstand long frost and dies at freezing temperature. In general the chilli plants require a temperature of 20°-25°C. Unfavourable temperature and water supply are the basic reasons for bud, blossom and fruit drops. It thrives in areas having a moderate rainfall within the range of 60 to 120 cm. Excessive rainfall, however, brings about defoliation and rotting of the plant. Chillies can be grown from the sea-level up to an altitude of 2000 metres.

Chilli crop is grown on practically all types of soils except on salty land provided the soil is well drained and well aerated. Where the seasons are short, sandy and sandy loam soils are preferred. As regards soil reaction, it is not very sensitive to soil acidity, but a strongly acid soil should be limed to make it moderate or slightly acidic.

Sowing Time

In Maharashtra, Andhra and Tamil Nadu the seed is sown in the nursery-beds from the third week of May to the middle of July. In the Gangetic valley it is sown in June and in the Punjab and Rajasthan where the harvest is to be completed before the onset of frost it is sown in April-May. The sweet pepper type is sown in August for the autumn-winter crop and in November for the spring-summer crop. In the hills sowing is done in March-April.

Seed Rate

About one to two kg of seed is required for one hectare, depending on the variety.

Transplanting

The seedlings are transplanted when they are about 4 to 8 weeks old according to the season of sowing. Some are of opinion that one extra transplanting in a second seed-bed gives an earlier and higher yield. The usual spacing in northern India is 45 cm and in southern India 55 cm from row to row and plant to plant. Experiments have, however, shown that closer spacings within the row ensure higher yields.

Manures and Fertilizers

Farmyard manure at the rate of 250 quintals for a dry crop and 500 quintals for an irrigated crop per hectare should be incorporated in the soil at the time of preparation. The application of 350 kg of ammonium sulphate, 175 kg of single superphosphate and 100 kg of potassium sulphate per hectare is recommended. Full doses of phosphate and potash and a half dose of nitrogen are to be applied at the time of transplanting and the rest of nitrogen as top-dressing. Use of a weak starter solution made of ammonium sulphate and potassium nitrate in ratio of 2 : 1 at the rate of 1 : 36 kg in 270 litres of water at the time of transplanting proves beneficial.

Irrigation and Interculture

In India the major areas under chillies are mostly rainfed. When there is insufficient rainfall the crop should be irrigated frequently. The maintenance of uniform soil moisture is essential to prevent blossom and fruit drop. Generally in India 8 to 9 irrigations are given depending on rainfall, soil type, humidity and prevailing temperature.

The weeds are kept in control and the soil is kept loose by interculture operations. Some weedicides like EPTC and CDEC are successfully used in foreign countries.

Hybrid Vigour

Higher early and total yields have been reported by use of F_1 seeds both in chilli and sweet pepper.

Harvesting

The stage of maturity at which chillies are picked depends on the type and purpose for which they are grown. Chillies which are used for vegetable purposes are generally picked while they are still green but full-grown. Those which are used for pickles are picked either green or ripe and chillies used for drying are picked red when fully ripe.

Yield

In case of a rainfed crop the yield of dry chillies is 500 to 1000 kg per hectare and that of an irrigated crop is 1500 to 2500 kg per hectare. Generally the yield of fresh green chillies is 3-4 times higher than that of dry chillies.

Seed Production

Chillies are cross-pollinated to a considerable extent. A distance of one-quarter of a kilometer between two varieties is desirable. The average yield of seed per hectare varies from 50 to 80 kg.

Diseases

Chillies are attacked by a number of diseases caused by fungi, bacteria and viruses. Some of the important diseases of common occurrence with their possible preventive and control measures are mentioned below:

Fusarium Wilt: It is characterised by wilting of the plant and upward and inward rolling of the leaves. The leaves turn yellow and die, the lower ones first, the upper ones finally. The fungus can live in the soil for several years, so the control measures consist of soil treatment or use of wilt-resistant varieties. Spraying with some copper fungicides also can prevent the spread of the disease.

Other fungal diseases are damping-off, *Phytophthora* blight, anthracnose and fruit rot. The control measures are similar to those of the fungal diseases for tomato.

The most important bacterial disease is bacterial spot.

The important virus diseases which attack chillies are tobacco mosaic, cucumber mosaic and curly top. There is yet no control measure known, other than hygienic condition, roguing of affected plants and spraying some insecticide to control the insect vectors. A variety **Puri Red** has been reported to be resistant to mosaic disease. Pusa Jwala has been derived from it. Blossom-end rot and sunscald are non-parasitic troubles of chillies that sometimes cause considerable loss.

Insect Pests

There are a number of insects which attack chilli but only thrips are often serious. The other insects are aphids, pepper weevils, and pepper maggots.

Thrips: These small insects suck the sap from the foliage. The control measures are timely dusting with 5 per cent BHC dust at the rate of 18 to 25 kg per hectare or spraying with 0.1% BHC at the rate of 400-500 litres per hectare. The treatments may not be given when the crop is ready for harvest.

Aphids: These transmit virus diseases and cause severe damage to the plant by sucking the sap. Spraying with parathion, malathion or nicotine sulphate controls the insect.

Pepper Weevil: The adult is a black beetle about 1/3 cm long with grey or yellow markings. The larva or grub is greyish-white with a pale-brown head. Both the adult and larva feed on the plant. Dusting or spraying with DDT can control the insect.

Pepper Maggot: The insect is about 1.2 cm long when full grown. The adult is two-winged, yellow-striped and about 10.5 cm long. The larva infests the pods. Repeated sprays with parathion or Malathion can control the insect.

CHAPTER VI

Cole Crops

THIS GROUP includes cabbage, cauliflower, kohlrabi, broccoli, Brussels sprouts and Chinese cabbage. This is a very important group of winter season vegetables. All cole crops are hardy and thrive best in cool weather except some acclimatized early cauliflower varieties. All crops of this group have developed from wild cliff cabbage, known as coleworts, from which the name 'cole' is derived. They all belong to the family Cruciferae and genus *Brassica*. They have many things in common in their cultural requirements.

CAULIFLOWER

(*Brassica oleracea* L. var. *botrytis*)
Hindi : *Phul Gobhi*

The cauliflower is one of the most important winter vegetables in India. According to an estimate of FAO 88,000 hectares were grown in India under cauliflower in 1978-79. In the plains of India it is available from September to May. Cauliflower is grown for its

(per 100 g of edible portion)

Moisture	90.8	g	Phosphorus	57	mg
Protein	2.6	g	Iron	1.5	mg
Fat	0.4	g	Sodium	53	mg
Mineral	1.9	g	Potassium	138	mg
Fibre	1.2	g	Copper	0.05	mg
			Sulphur	231	mg
Other carbohydrates	4.0	g	Vitamin A	51	I.U.
Calories	30		Thiamine	0.04	mg
Calcium	33	mg	Riboflavin	0.10	mg
Magnesium	20	mg	Nicotinic acid	1.0	mg
Oxalic acid	19	mg	Vitamin C	56	mg

white tender head or curd. It is a delicate crop and needs more care to grow successfully than most of the other vegetable. It is used as a vegetable in curries and soups, and for pickles. The nutritive value of the cauliflower is given in the table.

History and Origin

The name cauliflower has originated from the Latin words 'Caulis' and 'Floris' which mean cabbage and flower, respectively. Cauliflower, cabbage, kale and broccoli are all closely related and have originated from wild cabbage known as coleworts. These plants are still found in the wild state on the chalk rocks of the sea-coasts of England, on the coast of Denmark, in north-west France, and in various other localities from Greece to Great Britain. Cauliflower has been developed from these wild plants and originated in Cyprus and around the Mediterranean coast.

Taxonomy

All vegetables known as cole crops (cauliflower, cabbage, broccoli, Brussels sprouts, kale) have a common ancestor. They belong to the family Cruciferae, genus *Brassica* and species *oleracea*. The cauliflower is grouped in var. *botrytis*. Morphologically the curd is made up of numerous divided hypertrophic branches which terminate the main stem of the plant. It is a highly suppressed and extremely ramified hypertrophied flower stalk. No part of flower is apparent in a curd.

Varieties

The cauliflower varieties are very responsive to temperature and photoperiod. It is, therefore, very important to choose the right variety to be sown at the right time. Early varieties if sown late produce 'button' head and late varieties if sown early will go on giving leafy growth and will produce curd very late. Broadly speaking, cauliflower varieties can be grouped as early, mid-season and late. There are sub-groups within each group. We can call those varieties early which produce curds in the plains of northern India from the middle of September to the middle of November. The varieties which give cauliflower from the middle of November to the middle of January may be grouped as mid-season. The late varieties give curds from the middle of January to April.

Early:	**Kunwari** or **Kauri** and **Early Patna**—available from mid-September to mid-October. **Pusa Katki** and **Pusa Deepali**—available in October-November.
Mid-season:	**Aghani, Poosi, Patna Main Crop**—available from mid-November to mid-December. **Early Snowball, Giant Snowball, D-96, Japanese Improved, Pusa Synthetic**—available from mid-December to mid-January.
Late:	**Dania**—available in January-February **Snowball-16, Pusa Snowball 1** and **2**—available from mid-January to April.

The early varieties are smaller in size and have a yellowish tinge. The mid-season varieties produce the largest curds but are mostly dirty white in colour. The late varieties are compact and milky white in colour.

Climate and Soil

Cauliflower produces best curds in a cool, moist climate. There are, however, varieties which withstand a sufficiently high temperature. The foliage of cauliflower can withstand snow but the curd is damaged. The optimum monthly average temperature is 15-20° C, with the average maximum at 25° C and the minimum at 8° C. The early varieties require higher temperatures and longer day lengths. When other conditions are favourable, cauliflower can be grown on any good soil but a fairly deep, loamy soil is desirable. The soil should be fertile, well supplied with organic matter and well drained. The cauliflower is sensitive to high acidity. The optimum pH of the soil for maximum production should be between 5.5 and 6.6.

Sowing of Seed

The seed is sown in raised nursery-beds which should be sterilized by formaldehyde or some fungicidal treatment. The seed for early sowings should also be treated with some mercurial fungicide to save the young seedlings from damping off. Early sowing is done from the middle of May to the end of June. The sowing for the mid-season crop is done in July and August. The late crop is sown from the middle of September to the end of October.

Seed Rate

For early crops 600 to 750 g of seed are required and for late crops 375 to 400 g of seed are required per hectare.

Transplanting

The seedlings are transplanted when four to six weeks old, depending on the season in a well-prepared field. The planting distance depends on soil fertility, season, variety and market demand. In some markets small to medium sized curds are preferred to large-sized ones. Closer spacing is given for supplying cauliflowers to such markets. Generally, a spacing of 45 cm each way is kept for the early varieties and 45 cm from plant to plant and 60 cm from row to row for the late varieties.

Manures and Fertilizers

The cauliflower requires very heavy manuring as it removes large quantities of major nutrients from the soil. A yield of 50 tonnes per hectare removes approximately 220 kg of nitrogen, 85 kg of phosphate and 270 kg of potash.

The fertilizer practices differ in different regions. For best results, 15 to 20 tonnes of farmyard manure, compost or sludge should be applied per hectare three to four weeks before transplanting. Sixty kg of nitrogen, about 80 kg of phosphate and 40 kg of potash per hectare should be applied just before transplanting. A placement at 5 to 7 cm deep on both sides of rows is advisable. Another dose of 50-60 kg of nitrogen may be top-dressed about six weeks after transplanting. A cauliflower crop often shows boron and molybdenum deficiency symptoms when grown either on an alkaline or highly acidic soil. In such cases 10 to 15 kg of borax per hectare may be applied to the soil or two sprays with 0.3% borax on the seedlings may correct the boron deficiency symptoms. Molybdenum deficiency symptoms occur in highly acidic soils and can be corrected by liming or application of about 1-1.5 kg per hectare of sodium molybdate.

Interculture and Irrigation

Frequent shallow cultivation should be given to the soil to kill weeds and provide soil mulch. Cauliflower being a shallow-rooted crop, most of its roots are within 45-60 cm of the top soil.

Deep cultivation should, therefore, be avoided. The plants should be earthed up about four to five weeks after transplanting. Water must be supplied to ensure continuous growth. An early crop after transplanting may need irrigation twice a week and late crop once a week. During the later stage of the early crop and the early stage of the mid-season crop, irrigation is only given if there is a long gap in the rains.

Blanching

A perfect head of cauliflower is pure white. It is necessary to exclude sunlight to obtain this. While the head is small, it is protected by the inner leaves but later the curds are exposed. The common practice is to bring the outer leaves up over the head and tie them with a twine or rubber band. By using a different coloured twine or rubber band each day, it is easy at the time of harvest to select those tied earliest.

Harvesting, Grading, Packing and Storing

Cauliflower is harvested when the curds attain a proper size and before they begin to 'rice' or discolour. It is separated into three grades, depending on the size, colour, quality and variety. The usual method of packing and transport of cauliflower is in big nets and trucks. Tight packing is essential to prevent shifting and bruising. In some countries cauliflower is packed in crates and wire-bound boxes. Cellophane and transparent films are also used to pack cauliflowers which are hydro-cooled to remove field heat. Cauliflower with leaves attached can be stored for 30 days at 0° C with 85 to 90 per cent relative humidity.

Yield

The yield of cauliflower may vary from 20 to 30 tonnes per hectare. The early crops give low yields and the mid-season crops give high yields. It is possible to get yields even up to 50 tonnes per hectare.

Physiological Disorders

Browning (Brown-rot or *Red-rot)*: This is caused by boron deficiency. The trouble first appears as water-soaked areas in the stems and on the surface of the curd. Later, these areas change into a rusty-brown colour. Browning is associated with hollow stems. Other symptoms are changes in colour of foliage, thickening, brittleness and downward curling of older leaves.

Application of borax at the rate of 10-15 kg per hectare on acid soils controls browning, though the amount depends on the character of the soil, soil reaction and the extent of deficiency. On neutral and alkaline soils, a larger quantity should be used.

Whiptail: This results from the deficiency of molybdenum. Molybdenum becomes unavailable in very acid soils. Liming may correct the deficiency symptoms in such cases. There is varietal sensitiveness to molybdenum. The leaf-blades do not develop properly. In severe cases only the midrib develops, and whiptail can be prevented by bringing the soil pH to 6.5 by liming or by applying 1 kg of sodium or ammonium molybdate per hectare.

Buttoning: The term 'buttoning' is applied to the development of small heads or buttons. The plants do not develop normally and the leaves remain small and do not cover the developing heads. Deficiency of nitrogen is the main cause of buttoning. Planting early varieties late may also cause buttoning.

Blindness: Blind cauliflower plants are those without terminal buds. The leaves which develop are large, thick, leathery and dark green. Blindness is supposed to be due to low temperature when the plants are small, or due to damage to the terminal bud during handling of the plant or injury by insects and pests.

Diseases

Damping Off: It is a common problem in the nursery-bed of the early cauliflower. Drenching the nursery-bed with formaldehyde or some fungicide about three to four weeks prior to sowing, seed treatment with some mercurial fungicide and avoiding thick sowing are the common remedial measures.

Black Rot: Yellowing of affected leaves is followed by blackening of veins. Seedlings may die when attacked in the young stage. When the disease is severe, no curd may form. The disease is more severe in the hilly regions. This is caused by a bacterium *Xanthomonas campestris*, which is transmitted through seed and can be controlled by treatment with hot water at 50° C for 25-30 minutes and long crop rotations or by use of resistant varieties.

Soft Rot: It occurs in the field usually after an attack of black rot, or after mechanical injury of nearly mature curds. The causal organism is another bacterium known as *Erwinia carotovora.*

Clubroot: The roots show large swellings presenting a clubbed appearance. It is caused by a fungus *Plasmodiophora brassicae.* The foliage wilts on sunny days and recovers towards the evening. The disease is prevalent in acid soils. Avoiding cole crops in affected plots, long rotations without any cruciferous crops and keeping the soil alkaline are the control measures.

Phoma lingam: It affects all the parts of the plant. Infection often occurs on the stem of the young plants in the seed-bed or in the field, causing dark sunken areas. The wilting of the plants is characteristic of the advanced stages of this disease. Hot water treatment, at 50°C for 25 to 30 minutes, is effective in destroying the fungus in the seed.

Downy Mildew: is common in young plants and is characterized by the appearance of purplish brown spots on the underside of the leaves. Downy growth usually appears on the under surface of these lesions. The upper surface of the leaf on the lesion is tan to yellow. The causal organism is *Peronospora parasitica*, an obligate parasite. The primary inoculum being present in the soil, sanitation, and crop rotation help in reducing the infection. The disease also affects cabbage.

Sclerotinia Rot: has become a severe disease particularly for seed crops in the hills. The first indication of the disease is the appearance of water-soaked areas, which turn into brown patches. The lesion finally girdles the stem completely and makes it hollow. The rotting then affects the curd. The disease having a wide host range is caused by *Sclerotinia sclerotiorum*. The disease perpetuates in the soil through sclerotia, which are the resting structures of the fungus. At first these are pink but later turn black. They may vary in size and shape from round to flattened irregular. These remain buried in soil. Deep ploughing, hot weather cultivation are useful practices. Sometimes flooding the soil often destroys the sclerotia. Long, atleast 2-3 years rotation with crops which are not affected is recommended.

Insect Pests

Cabbage Maggot: The maggots first attack the young rootlets and then burrow into the main root, causing the plant to wilt. Dusting or application as a water suspension of Calomel or application of Aldrin or Dieldrin also controls the insect.

Green Cabbage Worm and Cabbage Looper—These feed on the foliage of cauliflower and can be controlled by spraying DDT or malathion 2-3 weeks prior to harvesting and by application of pyrethrum when the curds have formed.

Cabbage and Turnip Aphids: These insects are more injurious during the later part for the growth or when the crop is left for seed production. The attack is controlled by spray of malathion or parathion but if the curd is ready for harvest, nicotine sulphate is used.

Seed Production

Cauliflower is a cross-pollinated crop. Pollination is normally done by bees. Some bee-hives when kept in the seed production plots increase seed-set. Proper isolation is essential between varieties for the production of seeds. The seeds of early and mid-season varieties are produced in the plains of northern India. The seeds of late varieties are produced in the hills.

The best method of seed production is to leave the plants *in situ*. A very thorough roguing of off-type and undesirable plants is essential for quality seed production. The regions where early cauliflower seeds are commonly produced are U.P. and Bihar. Seeds can, however, be produced in other regions like Delhi, Punjab and Rajasthan. Early varieties can withstand transplanting if done with an earthball. The seed yield of transplanted plants may be slightly reduced. The seed yield of early cauliflower is about 400 to 500 kg per hectare. The production of seed of late cauliflower had been a problem for long. Techniques have now been developed and seed production of snowball varieties of cauliflower is now possible in the Kulu Valley, parts of the Kashmir Valley, Himachal Pradesh, the Darjeeling Hills and the Nilgiris. The sowing and transplanting time is to be adjusted for proper seed production. Chilling is required after the full vegetative phase is completed. If the temperature falls below freezing-point before the vegetative growth is full, the plant remains small and when the temperature again rises, very small curds form, thus giving a very low yield of seed. If transplanting is done early, curds may form before freezing temperature comes and the whole plant may be damaged. The sowing and transplanting times should be adjusted in such a manner that the plants put up maximum vegetative growth before the temperature goes low and the plants go into dormancy. For Kulu Valley, the optimum sowing time of the crop is the last week of August and the transplanting should be completed by the first week of October. Curd formation is completed by the first fortnight of March. Scooping the central portion of the curd when it is fully formed helps in the early emergence of the flower stalks. Approximately 250 to 400 kg of seed per hectare of this crop is produced.

CABBAGE

(Brassica oleracea L. var. *capitata)*
Hindi : *Bandh Gobhi*

Cabbage is one of the oldest cultivated vegetables used by the ancient Greeks and Romans. It is one of the most popular winter vegetables in India. It is grown in kitchen markets and truck gardens and covered an area of about 78,000 ha. in 1978-79. Cabbage is used as salad, boiled vegetable, cooked in curries, pickled as well as dehydrated vegetable. Cabbage is rich in mineral matters and in Vitamins A, B_1, B_2 and C. It is said to help digestion. The nutritive value of the cabbage is given below:

(per 100 g of edible portion)

Moisture	91.9	g	Phosphorus	44	mg
Protein	1.8	g	Iron	0.8	mg
Fat	0.1	g	Sodium	14.1	mg
Minerals	0.6	g	Potassium	114	mg
Fibre	1.0	g	Copper	0.08	mg
Other carbohydrates	4.6	g	Sulphur	67	mg
			Vitamin A	2000	I.U.
Calories	27		Thiamine	0.06	mg
Calcium	39	mg	Riboflavin	0.03	mg
Magnesium	10	mg	Nicotinic acid	0.4	mg
Oxalic acid	3	mg	Vitamin C	124	mg

History and Origin

The cabbage has originated from wild cliff cabbage as described under cauliflower. The original form is non-heading type. The head cabbage was referred to much later in about the 16th century.

Taxonomy and Varieties

The cabbage belongs to the Cruciferae family, genus *Brassica* and species *oleracea*. It is grouped as var. *capitata*. It is a biennial crop. There is great variation in the cultivated types of cabbage. They differ in size, shape and colour of leaves, and in size, shape, colour and texture of head. No attempt has yet been made to classify the varieties grown in India. The varieties commonly grown may be classified into the following groups:

1. Round head or Ball head types—**Golden Acre, Pride of India Copenhagen Market, Mammoth Rock Red, Express**
2. Flat head or Drumhead types—**Pusa Drumhead**
3. Conical head type—**Jersey Wakefield**
4. Savoy type—**Chieftain**

Round head types are the earliest followed by the conical types. The Drumhead and Savoy types are commonly late.

Climate and Soil

The cabbage thrives in a relatively cool moist climate. It is grown mainly as a winter crop in the plains of India. The main crop is grown in northern India where the winter temperature is relatively low. In the hills it is taken as a spring and early summer crop. In some parts, even two crops of cabbage are taken.

The cabbage can adapt itself to varied soil conditions. Sandy loam soil is considered best for an early crop but where a higher yield is the main criterion, clay loam or silt loam is preferred. It does not grow well in highly acidic soils. The optimum pH range for cabbage is between 5.5 and 6.5.

Sowing of Seed and Seed Rate

The seeds are sown in raised nursery-beds. They are sown in August-September for the early crop and in September-October for the late crop. In the hills they are sown from the beginning of March to the end of June for fresh vegetables and in July-August for seed production. The seed rate varies from 500 g per hectare for the early crop to 375 g for the late crop.

Transplanting

The method of transplanting is the same as for cauliflower except that the spacing for late drumhead types is kept more. Hardening of seedlings and use of starter solution at the time of transplanting give beneficial results.

Manures and Fertilizers

Cabbage is a shallow-rooted crop and is a heavy feeder. A 50-tonne yield per hectare of cabbage removes 220 kg of nitrogen, 100 kg of phosphate and 220 kg of potash. For best results in the plains of northern India 200 to 250 quintals of farmyard manure or compost are incorporated in the soil about three weeks before transplanting. About 325 kg of ammonium sulphate, 270 kg of superphosphate and 75 kg of muriate of potash are applied per hectare before transplanting. Another dose of 325 kg of ammonium sulphate should be top-dressed about five to six weeks later.

Irrigation and Weed Control

Cabbage requires a continuous supply of moisture. Heavy irrigation should, however, be avoided when the heads have formed. A sudden heavy irrigation after a dry spell may cause bursting of heads.

Hoeing and weeding should be done in between irrigations. Deep hoeing should always be avoided. Cabbage roots are surface feeders, so deep tillage will injure the feeding roots.

Harvesting, Grading and Storage

Cabbage is harvested when the head is of suitable size, firm but tender. The grading should be done according to the size and quality as per standards laid down by the Indian Standards Institution. The best storage temperature is 0°C at 90-95 per cent relative humidity. A good air circulation will avoid condensation if a uniform 0°C storage temperature is maintained.

Yield

The average yield varies from 30 to 35 tonnes per hectare for the early crop and 35 to 45 tonnes for the late crop.

Hybrid Vigour

Hybrid vigour has been reported in cabbage as in many other crops. F_1 hybrid seeds are used for uniform heads and a larger number of plants forming marketable heads rather than for large individual heads. Self-incompatible and cross-compatible lines or varieties with leaf gene-market are used for commercial F_1 hybrid seed production.

Diseases

The diseases and their methods of control are the same as those described under cauliflower. However, cabbage is susceptible to some other fungal diseases.

Black Leg: This disease, caused by a fungus, *Phoma lingam*, kills the base of the stem and roots and the plant wilts. Young plants in the seed-bed are very susceptible. The control measures are long crop rotations, seed treatment and hot water treatment of seed as in cauliflower. The variety **Pusa Drumhead** has field resistance to the disease.

Yellows: Plants become yellowish in two to four weeks after transplanting. The growth remains stunted and defoliation occurs. The control measures are clean seed-beds and growing resistant varieties. This disease is caused by *Fusarium oxysporum* f. *conglutinans* and is not a problem in India.

Insect Pests and their Control

These are the same as those for cauliflower.

Seed Production

The cabbage is a cross-pollinated crop and readily crosses with other members of the cole group. In India the seed is produced only in the hills. Three methods have been used for production of seed:

1. *Head intact method*: only a cross cut is given to facilitate the emergence of the flower stalk.
2. *The core intact method*: the outside leaves are removed and only the central portion is left from where the flower stalks come out.
3. *The stump method*: the head is removed and only the stump is left.

The last two methods in addition to some leafy vegetables give higher yields of seed. The defect is that the flower stalks become decumbent and pods nearly touch the ground. All the three methods can, however, be used after keeping proper isolation between varieties. In India cabbage seeds are raised in the Kashmir Valley, the Kulu Valley, the Simla and other hills in Hima chal Pradesh. This can also be raised in the U.P. hills. The seed yield per hectare is about 500 to 650 kg.

KNOLKHOL OR KOHLRABI

(*Brassica caulorapa* L.)

Hindi : *Ganth Gobhi*

Kohlrabi, which is the German name for cabbage-turnip, resembles an above-ground turnip. The fleshy edible portion is an enlargement of the stem, which develops entirely above ground. The nutritive value of Kohlrabi is given below:

(per 100 g of edible portion)

Moisture	92.7	g	Iron	0.4	mg
Protein	1.1	g	Sodium	112	mg
Fat	0.2	g	Potassium	37	mg
Minerals	0.7	g	Copper	0.09	mg
Fibre	1.5	g	Sulphur	143	mg
Other carbohydrates	3.8	g			
Calories	27		Vitamin A	36	I.U.
Calcium	20	mg	Thiamine	0.05	mg
Magnesium	18	mg	Riboflavin	0.09	mg
Oxalic acid	10	mg	Nicotinic acid	0.5	mg
Phosphorus	35	mg	Vitamin C	85	mg

Kohlrabi originated in the coastal countries of northern Europe. It belongs to the family Cruciferae, genus *Brassica* and species *caulorapa*. It is also known as *Brassica oleracea* var. *gongylodes*. There are two varieties commonly grown throughout India. They are **White Vienna**—the most common early variety with globular, light green, smooth, tender medium-sized knobs and **Purple Vienna**, is about a week later, the knobs are purplish and the flesh is greenish white. It is a cool season crop. The seeds are sown in lots from the end of August to the end of November for a continuous crop. About 1 kg to 1.5 kg of seed is sown in the nursery to cover one hectare. The usual spacing in the field is kept about 30 cm from row to row and 20 cm from plant to plant.

Other cultural operations are the same as for cabbage. A yield of 20 tonnes per hectare removes about 100 kg of nitrogen, 85 kg of phosphate and 170 kg of potash. When the swollen stems reach a diameter of 5 to 7 cm the plants are pulled out. The average yield per hectare may vary from 25 to 30 tonnes.

The diseases, insect pests and method of seed production are the same as those for cabbage.

CHINESE CABBAGE

(Brassica pekinensis and *B. chinensis)*

These are probably natives of China and are very commonly grown in China, Japan and South-East Asian countries.

Chinese cabbage demands the same soil and climatic requirements as cabbage. There are two more or less distinct species of Chinese cabbage, *Pe-tsai* (*B. pekinensis*) and *Pakchoi* (*B. chinensis*). Under the former are two popular varieties, **Chihili** and **Wong Bok**. Chihili produces a tall, narrow cylindrical head. Wong Bok is short and very chunky. *Pakchoi* is non-heading and has dark green rather smooth leaves with fleshy white petioles. Good quality Chinese cabbage can be produced only under a moderate to cool temperature (15° to 20°C). All cultural operations are the same as those for cabbage except that the seeds of Chinese cabbage can also be produced under north Indian plain conditions.

SPROUTING BROCCOLI

(Brassica oleracea var. *italica)*

Broccoli is an Italian word from the Latin *Brachium* meaning an arm or branch. In sprouting broccoli, a main head is produced terminally on a fleshy, branching, elongated stem. Besides the terminal head, longer, more slender and smaller heads appear in the axils of leaves. There are three types of broccoli, namely, green, white and purple. The green type which is most nutritive is the popular variety. There are also heading types of broccoli which are more like cauliflower. This is highly nutritive and contains 3.3 per cent protein and is rich in vitamins A, B_1, B_2 and C.

Italian Green Sprouting or **Calabrese** is the most commonly grown variety. **Bronzino** is a purple variety of the heading type.

The cultural operations and other requirements are the same as those for cauliflower. The seeding character is the same as the late mid-season type of cauliflower. It can freely seed at elevations of 1000 to 1200 m but can produce some seed in the plains of northern India as well.

BRUSSELS SPROUTS

(Brassica oleracea var. *gemmifera)*

This crop gets its name from the city of Brussels in Belgium, where it has been grown for several hundred years. The sprouts resemble miniature cabbages and are borne in the axils of leaves along and around the main stock progressively from the bottom upwards. The sprouts are usually cooked and also pickled. They have about 4.4 per cent protein and are fairly rich in Vitamin A and ascorbic acid and contain appreciable quantities of riboflavin, niacin, calcium and iron. There are dwarf (**Catskill, Early Dwarf, Dwarf Gem**), intermediate (**Long Island, Half Dwarf**) and tall (**Amager Market, Danish Prize**) varieties.

The cultural operations are the same as those for cabbage. In northern India it takes about 120 days to form sprouts. Often the terminal buds or lower leaves are removed to get good and early sprouts. Removal of terminal buds may produce larger sprouts but the number is decreased. Removal of lower leaves may reduce the yield.

The seeds, as those of cabbage, are only produced in the Himalayas at 1200 m and above.

CHAPTER VII

Root Crops

THE IMPORTANT commercial crops grown under this group are radish, turnip, carrot and beet. A number of other root vegetables, which are commercially less important, are also included in this group. They are parsnip, rutabaga, salsify, chervil, skirret and celeriac. All these crops thrive well in a cool season. However, a number of varieties of radish, turnip and carrot have been developed which grow well in a comparatively warm season. All the root crops though belonging to a number of different families need nearly the same cultural requirements.

RADISH

(Raphanus sativus L.)

Hindi : *Muli*

The radish is a very popular root crop throughout India. Radishes are very useful as inter-crops or companion plantings between rows or plants of slower growth. It is grown for its fleshy edible roots which are eaten raw or as salad or cooked. The fruits of radish are also cooked as a vegetable. Radish tops are cooked as

(per 100 g of edible portion)

Moisture	94.4	g	Phosphorus	22	mg
Protein	0.7	g	Iron	0.4	mg
Fat	0.1	g	Sodium	33	mg
Minerals	0.6	g	Potassium	138	mg
Fibre	0.8	g	Vitamin A	5	I.U.
Other carbohydrates	3.4	g	Thiamine	0.06	mg
Calories	17		Riboflavin	0.02	mg
Calcium	50	mg	Nicotinic acid	0.5	mg
Oxalic acid	9	mg	Vitamin C	15	mg

leafy vegetables and are very rich in minerals and vitamins A and C. The nutritive analysis of radish roots is as below:

History and Taxonomy

The history of this crop is vague. It probably came from Central and Western China and India, where it was used as food long before recorded history. Wild radishes are found in the Mediterranean region.

Radish is both annual and biennial and belongs to the Cruciferae family, genus *Raphanus* and species *sativus*. The fleshy edible portion of the root develops from both the primary root and the hypocotyl.

Varieties

Radish roots vary greatly in size, shape and exterior colour, as well as the length of time for which they remain edible. The radish varieties can be divided broadly into two groups—European or temperate type and Asiatic or tropical and subtropical types. The temperate types are small in size, mild in taste and are mostly raised as salad crops. The most common varieties grown are:

White Icicle: A pure white, thin and tender variety which becomes ready in about 30 days after sowing.

Pusa Himani: A long white variety released by I.A.R.I. It is suitable for sowing from middle of December to late February in the plains and during summer in the hills

Rapid Red White Tipped or **Scarlet Globe** or **French Breakfast:** These globular varieties become ready in 26 days.

Among the tropical types most common are:

Japanese White: Roots grow better when the temperature is low. They are pure white, 30 to 45 cm long, mildly pungent and with a blunt end.

Pusa Desi: Roots are of the same size as those of the Japanese White and have a green stem end. They are more pungent, have tapering roots and are suitable for sowing early in August.

Pusa Chetki: Roots are pure white, mild pungent. It is suitable for sowing from March to August. The roots become ready for harvest in 40 to 45 days.

Pusa Reshmi: Roots are 30 to 35 cm long, tapering white with green stem end. It is suitable for sowing in September.

Hill Queen: A popular variety in north India for sowing in September onwards

The other good Indian varieties are **Jaunpuri** (giant varieties more than one metre long). **Bombay Red, Chinese Rose, Contai.** Some of the Japanese varieties like **Sakurajuma** grow to enormous size and have solid, firm flesh.

The rat-tail radish (*Raphanus sativus* var. *caudatus*) is exclusively grown for its long, pods and is cooked as a vegetable.

Climate

Radish is tolerant to heat but to develop its flavour, texture and size, a cool season with temperatures between 10°C and 15°C are required. However, this depends on the variety.

Soil and Manures

Radish is grown on all types of soil, but a light, friable soil is considered best. The soil should be thoroughly prepared so that there are no clods to interfere with the development of the root. For a yield of 20 tonnes per hectare of radish the removal is 120 kg of nitrogen, 65 kg of phosphate and 100 kg of potash. Since the crop grows so rapidly, a rich fertile soil is essential.

Sowing Time and Seed Rate

The radish is sown on ridges. The distance between the ridges and the spacing within rows depend on the variety. The temperate types which become ready in 25 to 30 days are sown closely, whereas the tropical types take a longer time and being larger in size are given wider spacing. These seeds are sown from August onwards and the temperate types from the middle of September onwards. The tropical types sown later than November bolt early. Often another spring-summer crop of radish is taken. In places where the climate is mild, radish can be grown all the year round. Ten kg of seeds are required to sow one hectare with the large varieties and 12 kg for the temperate types.

After-care

Radish requires plenty of water from sowing time until the roots are large enough to be pulled out. The larger varieties need earthing-up at least once and this operation is sufficient to keep out weeds.

Harvesting

Radish should be harvested when the roots are still tender. A few days' delay in harvesting, particularly the temperate types, may make the roots pithy and quite unsuitable for the market. The roots are pulled out along with the tops and washed and then packed for the market.

Yield

The European varieties yield about 8,000 to 12,000 kg per hectare, whereas the Asiatic types may yield between 20,000 and 33,000 kg.

Seed Production

The seeds of the temperature types are produced only in the hills. The tropical types produce seed in the plains. The variety Japanese White, though it can produce seeds in the plains, yields more when on the hills. The radish is a cross-pollinated crop. Honey bees are important agents of pollination. Seed yield is greatly influenced by the number of honey bees visiting the crop. Nectar secretion, available pollen and bee activity are all affected by environment. Temperatures of 33° C or higher cause the stigmas to become dry and pollen grains fail to germinate. The roots left *in situ* produce the highest quantity of seed. However, to produce quality seed the roots are to be pulled out, examined for their characters and then replanted. The usual practice is to remove a half to three-fourths of the lower root before planting. This process reduces the yield considerably. It is, therefore, advisable to cause as little injury to the roots as possible before transplanting. The seed yield per hectare is about 600 to 800 kg according to the variety.

Insect Pests

The most important insect attacking radish is the aphid. This insect can be controlled by spraying nicotine sulphate, if the radish is to be harvested within a week, or with Malathion. Soil application of Furadan at the time of sowing controls aphid in young seedlings. The other insects attacking radish are the cabbage root maggot and flea beetles.

Diseases

There are no important diseases. Sometimes there may be stray cases of mosaic and rust.

TURNIP

(Brassica rapa L.)
Hindi : *Shalgum*

The turnip is widely cultivated in north India, mainly for its root. The turnip greens though seldom used as green vegetable are often fed to cattle. The young tops are very rich in mineral matter and vitamins. The turnip is used as salad, cooked or pickled. The following is the analysis of the nutritive value of turnip but it will vary considerably from variety to variety:

(per 100 g of edible portion)

Moisture	91.6 g	Iron	0.4 mg
Protein	0.5 g	Thiamine	0.04 mg
Fat	0.2 g	Riboflavin	0.04 mg
Minerals	0.6 g	Nicotinic acid	0.5 mg
Fibre	0.9 g		(green leaf 5.4)
Other carbohydrates	6.2 g	Vitamin A	Nil
Calories	29	(green leaves contain 15,660 I.U.)	
Calcium	30 mg	Vitamin C	43
Phosphorus	40 mg	(green leaf 180 mg)	

History and Taxonomy

It is not definitely known where the turnip originated. It is said to have been found growing wild in Russia and Siberia. The other possible centres of origin are (*a*) Central and Western China and (*b*) Middle Asia (the Punjab and Kashmir) or the Mediterranean. The turnip has been used by man for four thousand years or more.

The turnip belongs to the family Cruciferae, genus *Brassica* and species *rapa*. Sometimes it is put under species *campestris* and var. *rapa*.

Varieties

As in the case of radish, turnip varieties can also be put into two groups, European or temperate and Asiatic or tropical. The temperate varieties are sweeter and more palatable, whereas the tropical types are more pungent and better for pickles. The tropical types are earlier and more heat-resistant. Some of the good varieties under the temperate types are **Purple Top White Globe, Snowball, Golden Ball, Early Milan Red Top, Pusa Swarnima** and **Pusa Chandrima.** The tropical types are either red or white, **Pusa Kanchan** is a selection from a cross of red Asiatic variety and Golden Ball and is intermediate in maturity. **Pusa Sweti** is very early and snowwhite in character.

Climatic and Soil Requirements

These are the same as those for radish. A light dose of 20 to 25 tonnes of farmyard manure per hectare should be applied before preparation of the land. This should be supplemented by 35 kg of nitrogen, 50 kg each of phosphate and potash initially before sowing the seeds. Another dose of 35 kg of nitrogen should be top-dressed when the roots just start forming.

Sowing Time and Seed Rate

The tropical types can be sown from the end of July to September and the temperate types from September to December in the plains of northern India. In the hills, they are sown from March to May. The seed rate per hectare is about three to four kg.

All other cultural operations are the same as those for radish.

Yield

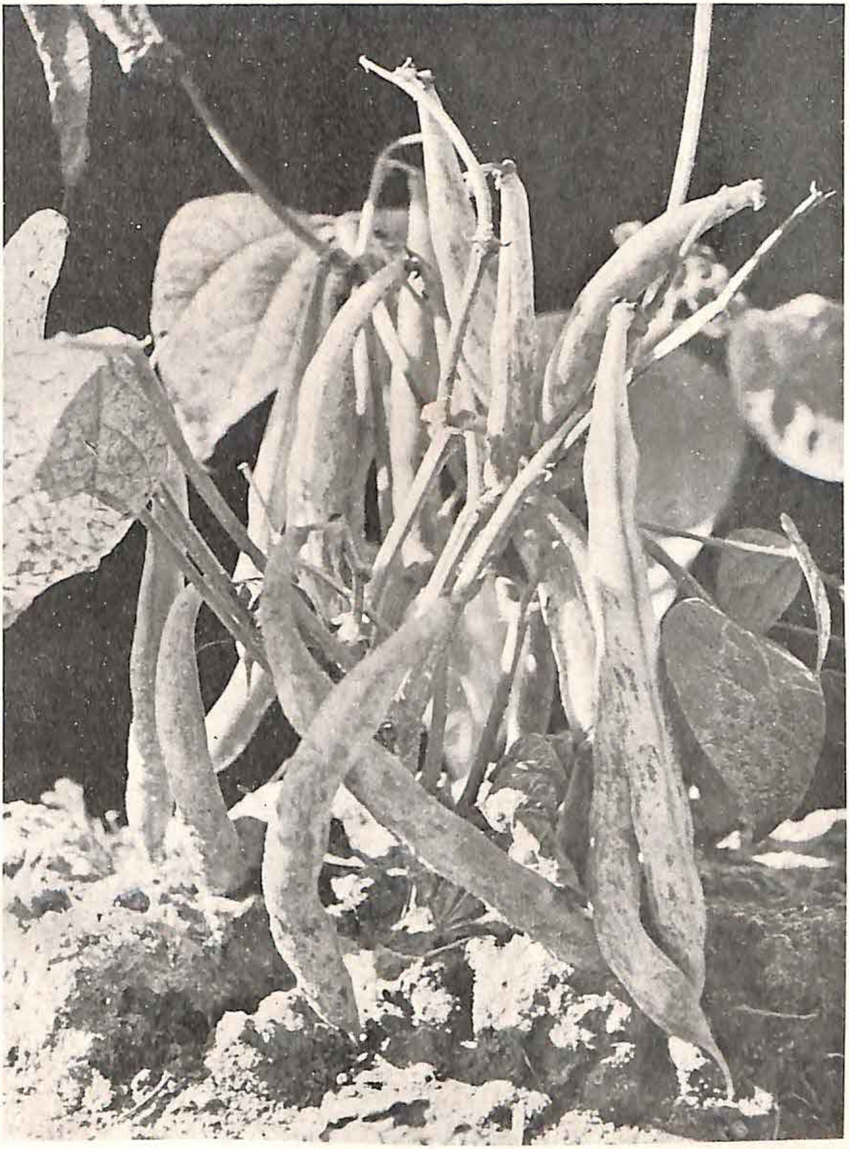
The yield varies from 30,000 to 40,000 kg per hectare.

Seed Production

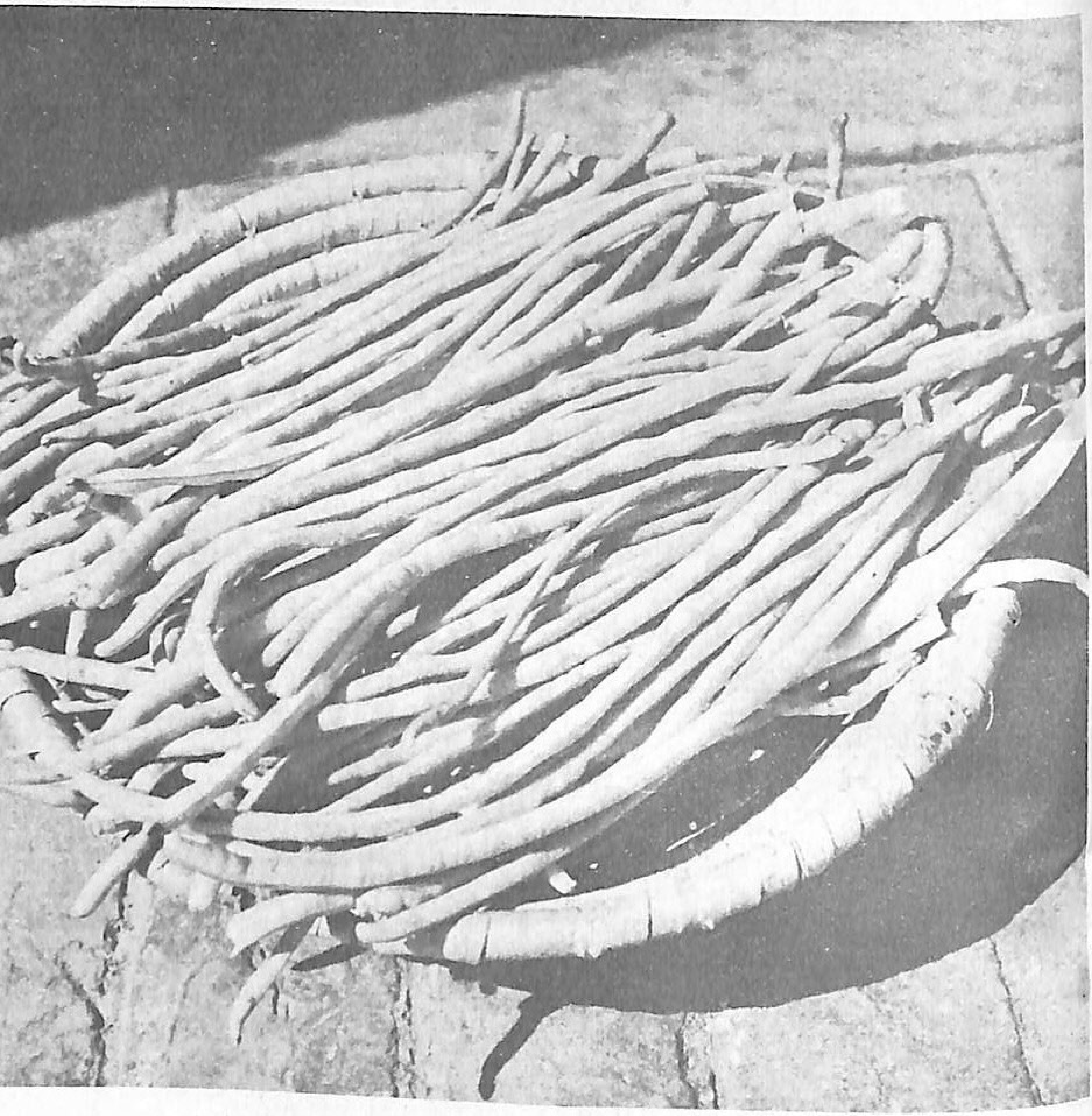
The method of seed production is the same as that for radish. The seeds of the tropical types are produced in the plains, whereas those of the temperate types are produced on the hills. It crosses readily with mustard. So proper isolation against contamination with mustard is necessary. For good quality seeds the roots after formation should be dug out, selected and transplanted for seed production. The average yield of seed per hectare will vary from variety to variety and may be about 550 kg.

Insect Pests

The most serious pest is aphid as in radish. Other insects are root maggots and beetles.



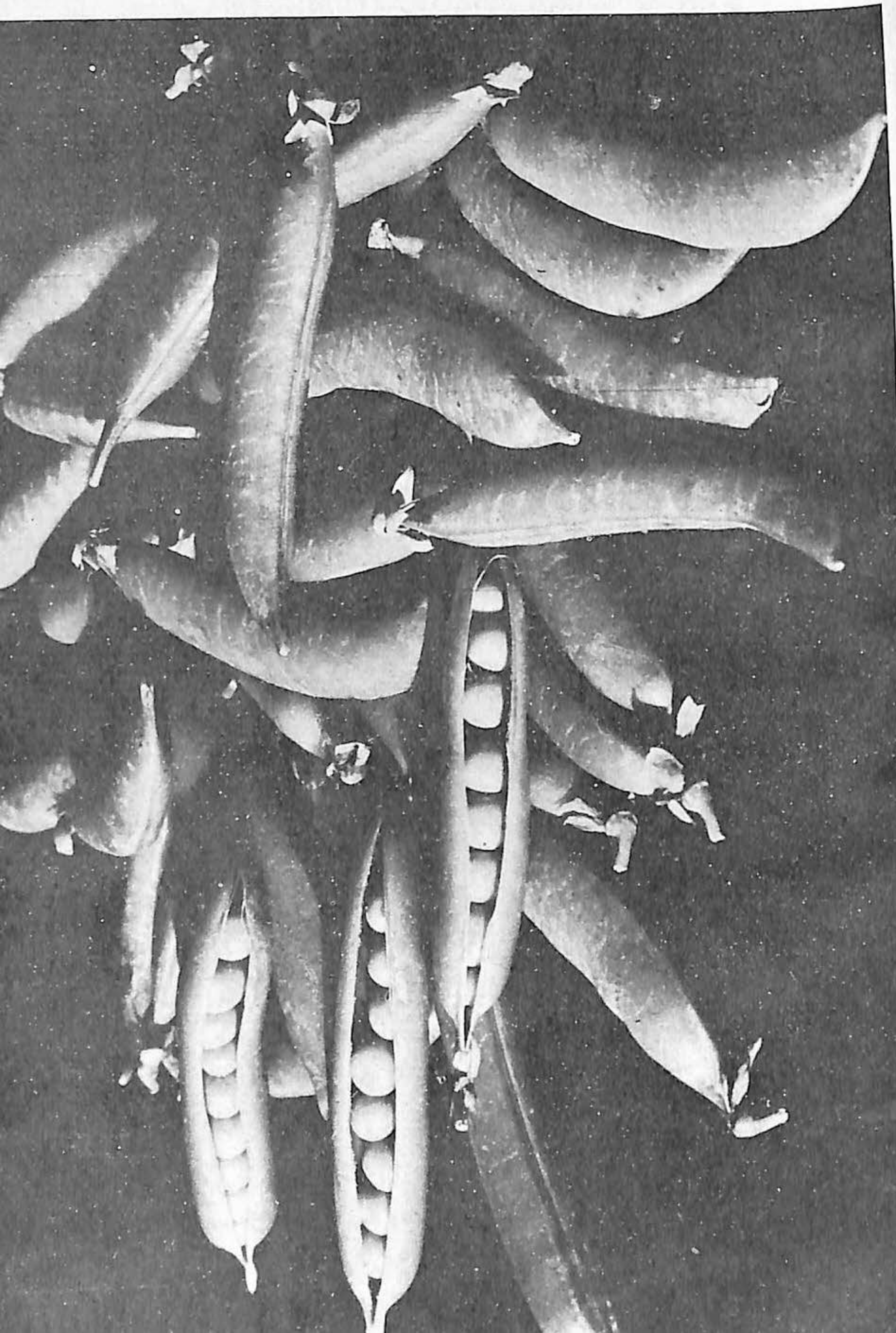
French Bean *Contender*



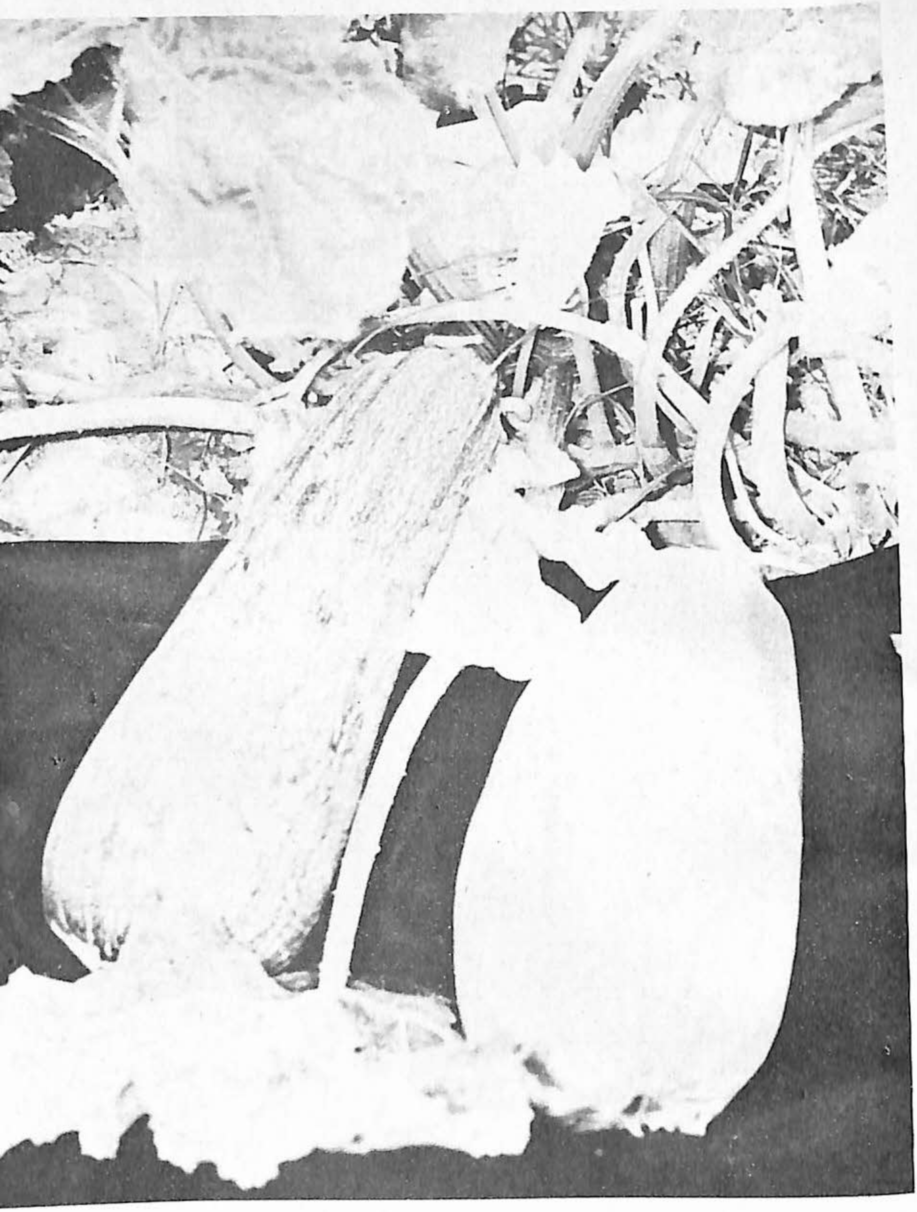
Cowpea *Pusa Dofasli*

Winged Bean

Peas *Arkel*

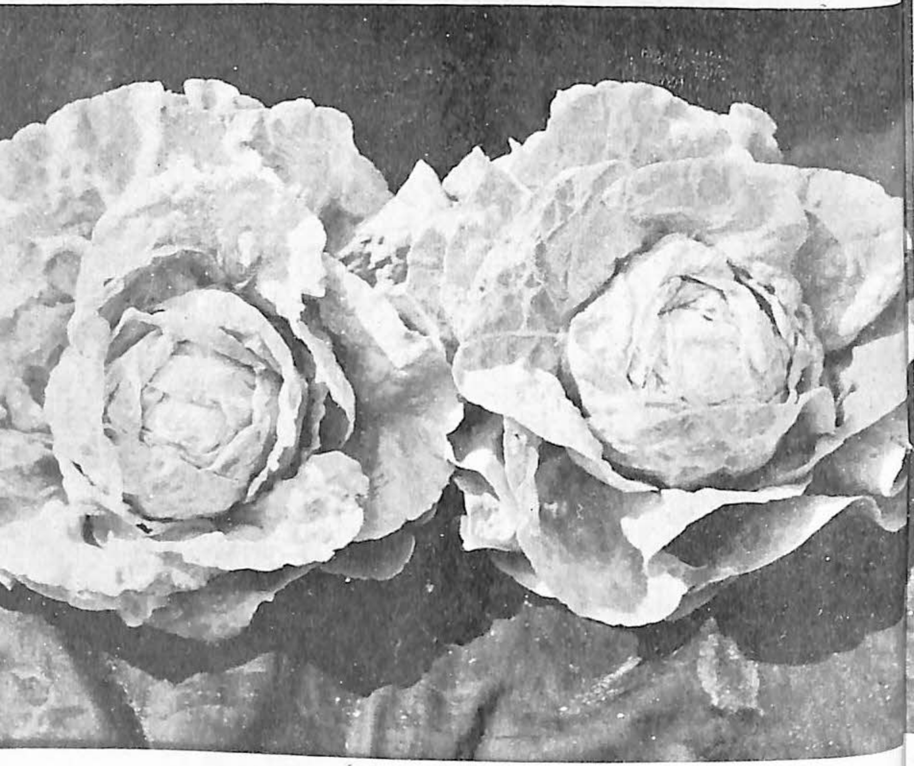


Pumpkin *Pusa Vishwas*



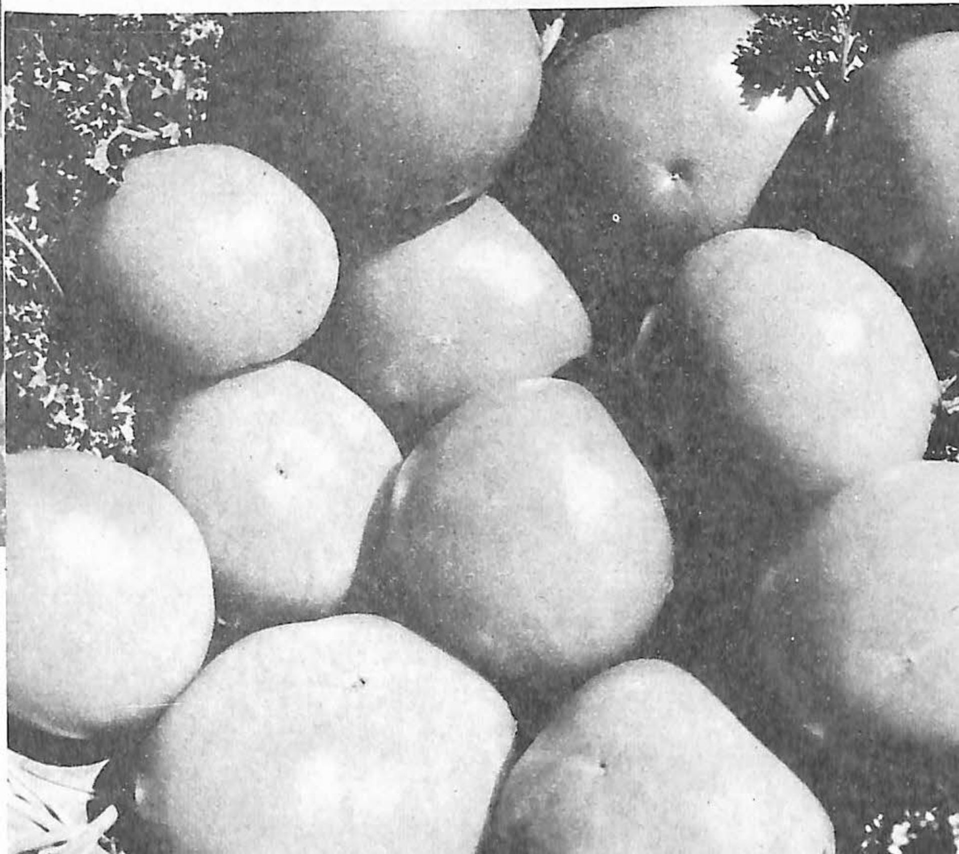
Squash *Summer Squash*

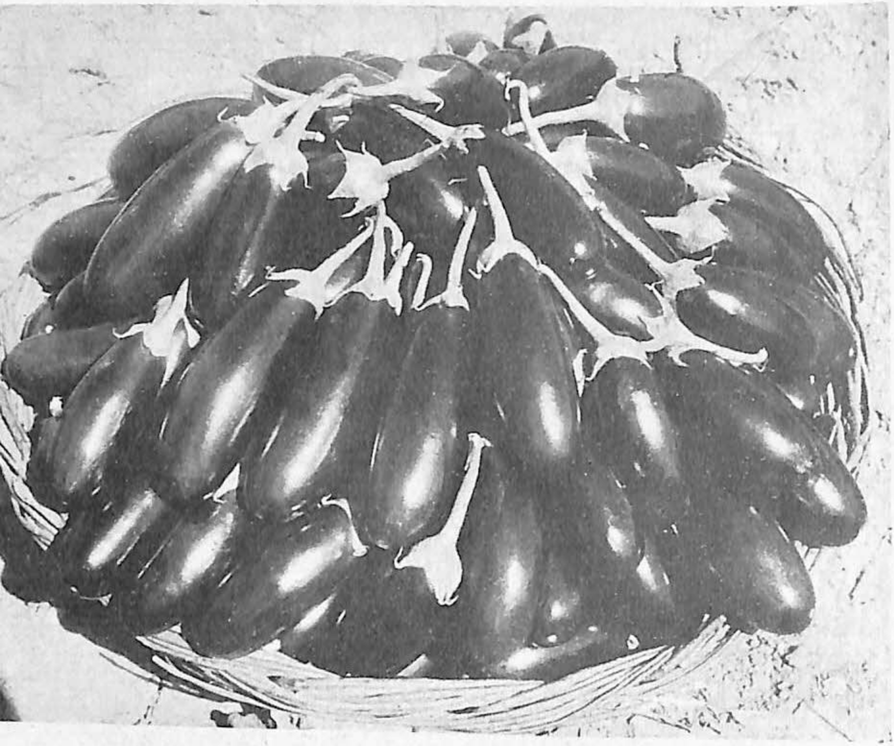
Okra *Pusa Sawani* →



Lettuce *Great Lakes*

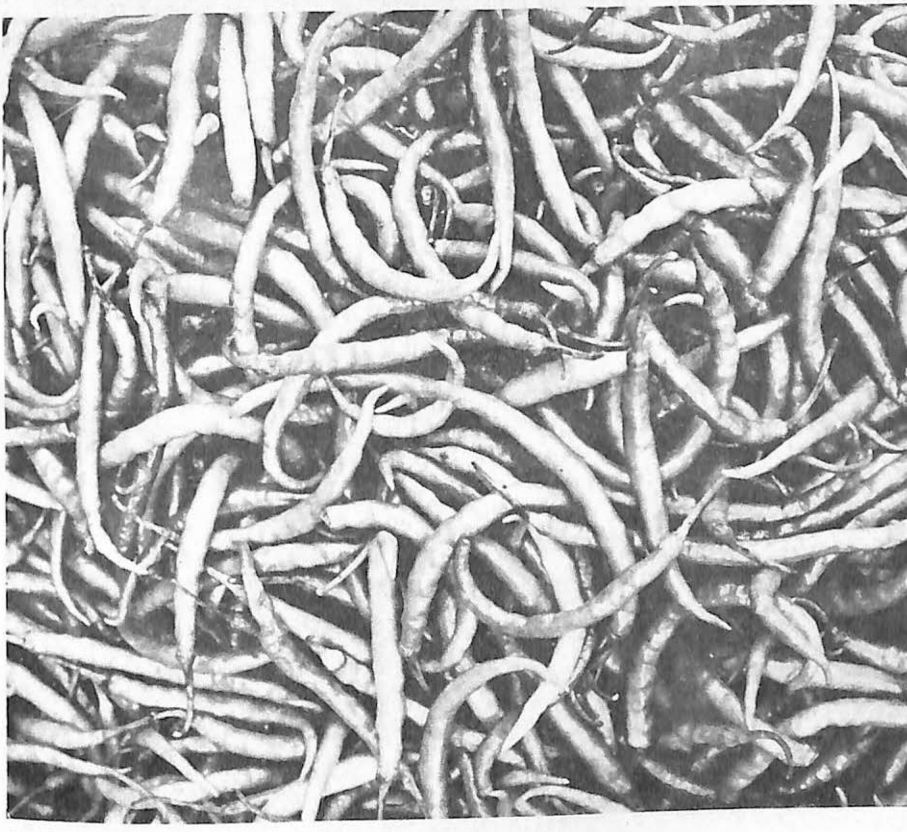
Tomato *Pusa 120*



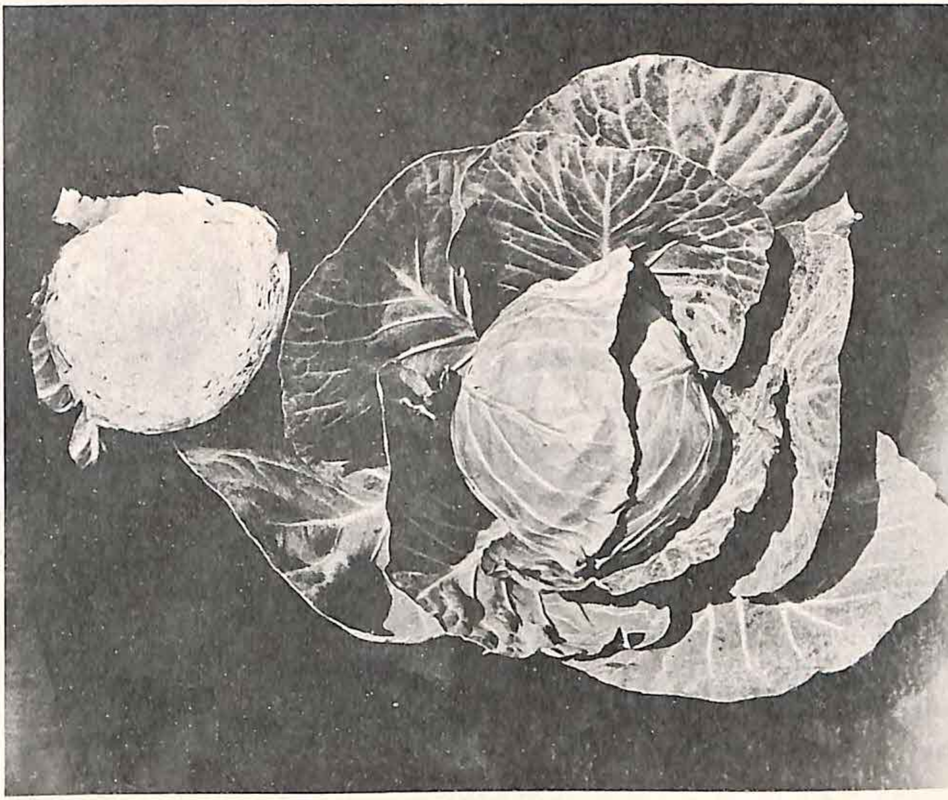


Brinjal *Pusa Kranti*

Chilli *Pusa Jwala*



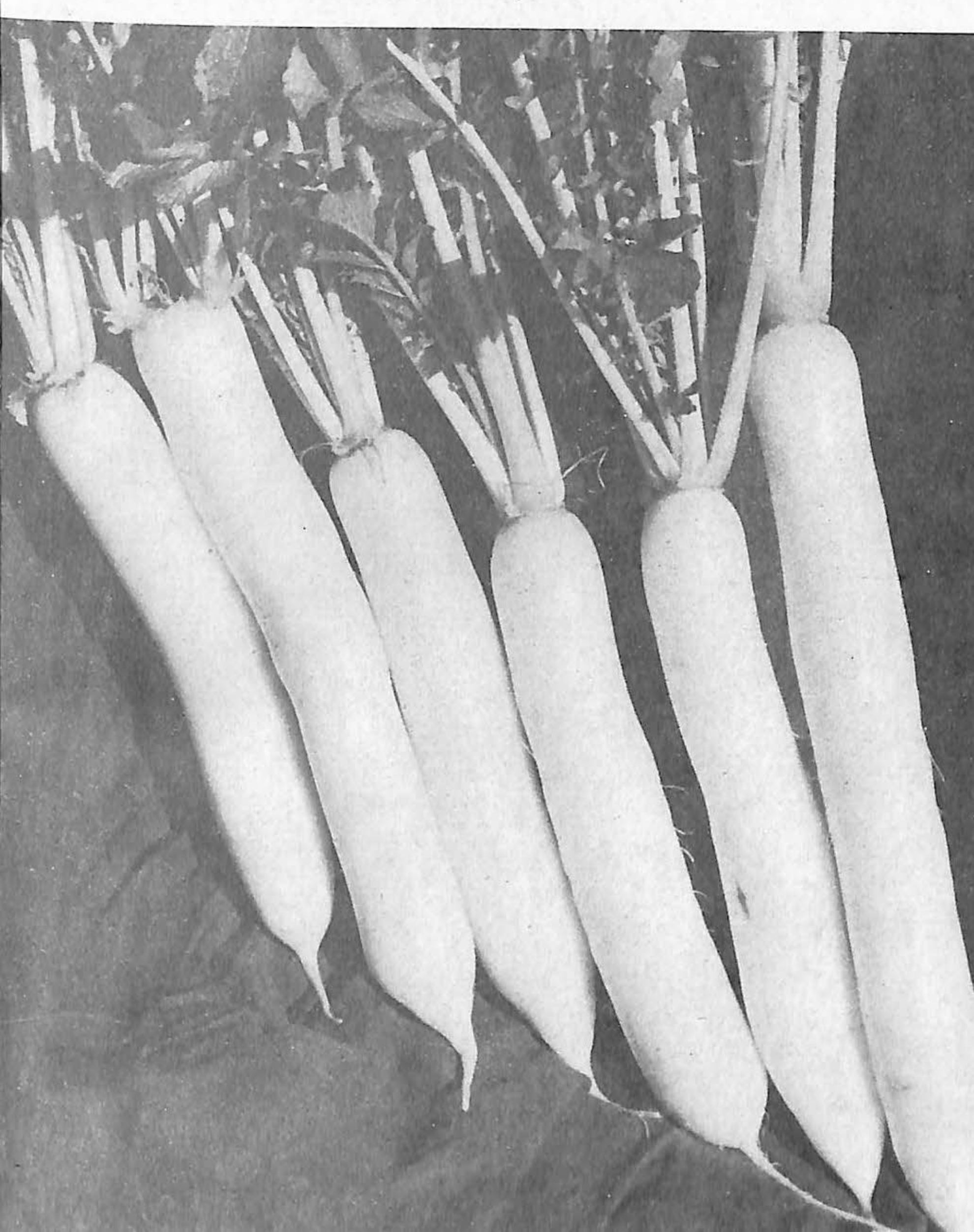
Cauliflower *Snowball*



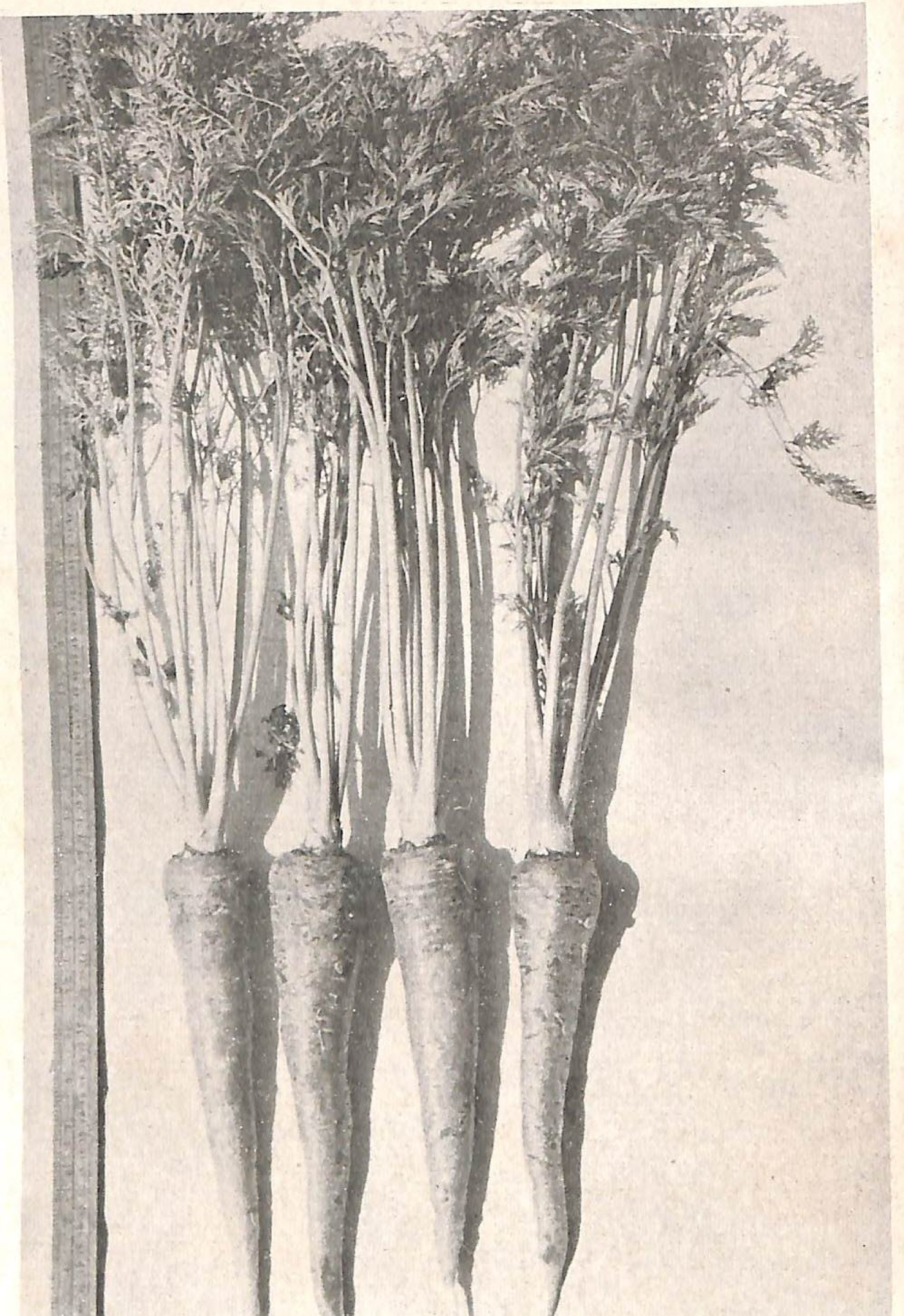
Cabbage *Golden Acre*

Knol-Khol *White Vienna*

Radish *Japanese White*



Carrot *Pusa Kesar*



Diseases

Clubroot and black rot diseases (discussed under cabbage) also attack turnip.

CARROT

(*Daucus carota* L.)

Hindi : *Gajar*

The carrot is grown all over India and is used for human consumption as well as for forage and particularly for feeding horses. It is taken raw as well as cooked in curries and is made into pickles and sweetmeats. Black carrots are used for the preparation of a sort of beverage called *kanji* which is supposed to be a good appetizer. The orange-coloured varieties are rich in carotene, a precursor of vitamin A, and contains appreciable quantities of thiamine and riboflavin. The nutritive analysis of this type of carrot is given below:

(per 100 g of edible portion)

Moisture	86.0 g		2.2 mg
Protein	0.9 g	Sodium	35.6 mg
Fat	0.2 g	Potassium	08 mg
Minerals	1.1 g	Copper	0.13 mg
Fibre	1.2 g	Sulphur	27 mg
Other carbohydrates	10.6 g	Vitamin A	3,150 I.U.
Calories	47	Thiamine	0.04 mg
Calcium	80 mg	Riboflavin	0.02 mg
Magnesium	14 mg	Nicotinic acid	0.6 mg
Oxalic acid	5 mg	Vitamic C	3 mg
Phosphorus	30 mg		

The Asiatic types have more of anthocyanin pigments and less of carotene and may be less nutritive. Green carrot leaves are highly nutritive, rich in protein, minerals and vitamins.

History and Taxonomy

The carrot probably originated in Central Asia in the hills of the Punjab and Kashmir with a secondary centre of distribution in Asia, Europe and North Africa around the Mediterranean. It belongs to the family Umbelliferae, genus *Daucus* and species *carota.*

Varieties

As in radish and turnip, carrot varieties can be grouped into two types—the temperate and the tropical. The temperate types are biennial, whereas the tropical types are annual. Very little work has been done to improve the tropical types. A wide range of colour from black and red to yellow is found in this group. They are more juicy and have a bigger core, a heavier top and can be grown much earlier than the other type.

Pusa Kesar: Originally a cross between two groups, this has been selected as it behaves like a tropical type.

Pusa Meghali: is another recent selection

In the temperate types which are orange-coloured, the well known varieties are:

Half-Long Nantes, Pusa Yamdagni and Coreless: which are stump-rooted, have well-shaped orange roots, are perfectly cylindrical, sweet and have a self-coloured core.

Chantaney: has an attractive thick reddish orange colour, roots tapering slowly with an abrupt blunt tip.

Climatic Requirements

The carrot is a cool season crop though some of the tropical types tolerate quite high temperatures. The colour development and the growth of the root are affected by temperature. Carrots grown at 10°C to 15°C develop poor colour. Those grown at 15°C to 20°C will develop a good colour; while at 20°C to 25°C the colour will be less bright. The highest temperatures, however, produce shortest roots and the longest roots are produced at the lowest temperature of 10°C to 15°C. The effect, of course, will vary with the soil conditions and the variety.

Soil and Fertilizers

Carrots need a deep, loose, loamy soil for their best development. Highly acidic soils do not produce good carrots. The maximum yield is expected around pH 6.5. Yields are extremely low at pH 2.5 or less. The carrot is a gross feeder, especially of potash. It is estimated that a yield of about 275 quintals per hectare will remove 125 kg of potash, 40 kg of nitrogen and 22.5 kg of phosphate. Fresh cowdung should not be applied to a carrot field as it may result in branching of roots. Well-rotted farmyard manure should be applied at the rate of about 30 tonnes per hectare and should be supplemented by nitrogenous, potassic and phosphatic fertilizers according to the fertility of the soil.

Sowing Time and Seed Rate

In the plains carrots are sown from the middle of August to the beginning of December. The tropical types are first sown while the temperature remains high. These can be sown till the end of September or the beginning of October. The sowing of the temperate types should be started after that. In the hills carrot is sown from March to July.

Several successive sowings, at intervals of 2-4 weeks, help to ensure a continuous harvest of marketable roots. The seeds are sown on ridges or on flat land about 1.5 cm deep. Five to six kilograms of seed can suffice for one hectare. Carrot seed takes about a week to germinate.

After-care

If the sowing is done thick, thinning should be done to allow each root enough space for its proper development. Carrot roots do not come up like those of radish and normally do not need any earthing-up. The seedlings grow slowly at first, and cannot compete with weeds. Removal of weeds is necessary especially in the earlier stages. The soil should be hoed from time to time to allow proper aeration. Certain weed-killers are very effective in a carrot field. Most common in use in some countries is Stoddard solvent, a petroleum product, at the rate of 700 to 1400 litres per hectare. Care should be taken not to use it several weeks before harvest and when the temperature is high. Insufficient moisture will result in low yields. However, excessive amounts of water may decrease yields. Corrots should be irrigated before any wilting of leaves takes place.

Harvesting and Yield

Early carrots for the market are pulled out when partly developed. They are normally dug out, when the soil is sufficiently moist, with a spade or a *khurpa*. The roots are trimmed and washed before sending them to the market. The yield of carrot varies with the variety. The tropical types usually give high yields. The yield varies from 20,000 to 30,000 kg per hectare.

Seed Production

The tropical types produce seed in the plains of India. The seeds of the temperate types are produced in the hills. It is a cross-pollinated crop. Honey bees and house flies are the main pollinators. The inflorescence is a compound umbel normally called a head. There is a single central or primary head. Flowers usually begin to open on the periphery of the central head first. About eight days later the process starts in one or more of the secondary heads. The time required for the entire umbel to pass through the flowering period is about seven to ten days. More quantity of seed is produced when the roots are left *in situ*. However, for quality seed production, the roots should be dug out, selected and then transplanted. The seed-yield per hectare is about 500 to 600 kg.

Insect Pests and Diseases

There are yet not many serious insect pests or diseases of carrots in India. Among the insects some of which are important are carrot weevil, six-spotted leaf hopper and carrot rust fly. Carrot yellows is a virus disease transmitted through the six-spotted leaf-hopper. Bacterial soft rot sometimes can be serious and can be controlled by treating the seeds with a mercury compound, and by long rotation. Other diseases are leaf spots and blights, which can be controlled by copper or carbamate sprays.

BEET

(*Beta vulgaris* L.)
Hindi : *Chukandar*

Garden beet is an important home and market garden crop in the U.S.A. and Europe. It is not so important in India as radish, turnip or carrot. Beet is eaten raw as salad, cooked with other vegetables and with meat and is also grown for processing. Beetroot is rich in minerals and vitamin C. The nutritive analysis of beet-root is as follows:

(per 100 g of edible portion)

Moisture	87.7 g	Iron	0.4 mg
Protein	1.7 g	Sodium	59.8 mg
Fat	0.1 g	Potassium	43 mg
Minerals	0.8 g	Copper	0.20 mg
Fibre	0.9 g	Sulphur	14 mg
Other carbohydrates	8.8 g	Vitamin A	Nil
Calories	43	Thiamine	0.04 mg
Calcium	200 mg	Riboflavin	0.09 mg
Magnesium	9 mg	Nicotinic acid	0.4 mg
Oxalic acid	40 mg	Vitamin C	88.0 mg
Phosphorus	55 mg		

History and Taxonomy

Beets were well known in ancient Greece and Rome, but it was the leaves that were eaten. The roots developed earlier were of a long carrot-like shape. The native place of beet is probably the Mediterranean region of Europe or around Western Asia and Africa.

It belongs to the family Chenophodiaceae. The garden beet, sugar beet, swiss chard, mangel, *palak*, all belong to the same genus and species *Beta vulgaris*. Beet root is a biennial crop.

Varieties

The varieties are grouped according to their shape. They are flat, short-top shaped, deep oblate to round, globular to oval, half-long and long. The two varieties which are most commonly grown in India are **Crimson Globe** and **Detroit Dark Red**, both belonging to the globular to oval group.

Climatic Requirements

Beet is considered to be a cool weather crop but can also be grown in warm weather. Under cool weather, the roots have a high sugar content. Good colour is not directly related to high sugar but a low sugar content is associated with poor colour. Temperature has a pronounced effect on the crop with regard to maturity and seeding. At temperatures below 10°C, the crop goes to seeding before attaining marketable size.

Soil and Manurial Requirements

All soils are suitable as long as they are friable enough for proper development of roots. The beet plant is sensitive to soil acidity. The yield increases when the acidity is reduced from pH 5.0 to 5.8. The yields at pH 5.8 to 7.0 essentially remain the same. The beet must make rapid and continuous growth to develop the best quality. On sandy loams, organic manures are essential to supply humus and other nutrients. One tonne of beet-root removes 2.25 kg of nitrogen, 4.5 kg of phosphate and 4.5 kg of potash. For an average soil, the manurial recommendation is 60-70 kg nitrogen. 100-120 kg of phosphate and 60-70 kg of potash per hectare. On sandy soils, the quantities of nitrogen and potash should be increased. Beets have a relatively high boron requirement; its deficiency causes internal breakdown as black spot or dry rot. Nitrate sources of nitrogen are preferred to ammonium sources.

Seed Sowing and Seed Rate

Seed is sown at the same time as carrot and 5-6 kg of seed is required for one hectare.

After-care and Harvesting

More than one seedling germinates from each seed. Thinning therefore is an essential process. Many weeds in beet fields can be controlled by a spray of common salt. The spray should be applied when beet plants have three to five true leaves. The most common concentration is two kg of salt per 10 litres of water. Other operations and harvesting are done as in the case of carrot.

Yield

20,000 to 25,000 kg per hectare.

Seed Production

The Beet-root seed is produced above 1,200 m in India. It is a cross-pollinated crop, generally pollinated by wind. About one and a half kilometres of isolation is required between varieties for commercial seed and about three kilometres for nucleus and foundation seeds. About 2000 kg of seed can be produced from one hectare. The so-called beet seed in reality is a fruit. Each fruit contains two to six seeds. The actual seed is small kidney-shaped and brown in colour. That is why thinning is essential in beet, as at each place two to three seeds germinate. To avoid this extra labour, varieties with a single seed in each fruit have been developed.

Insects and Diseases

Beet leaf-miners can be controlled by spraying Malathion. Other insects which may attack beet are flea beetles and beet web worms. Leaf spot disease is quite common. Ploughing under the old affected leaves and repeated sprays of any copper fungicide can control the disease. Rhizoctonia root rot affects the crown of the root. Rotating beets with onions, peas and other resistant crops reduces the trouble. Potato, tomato or lettuce should not be grown in this rotation as the same fungus affects them.

Other Root Crops

Other root crops which are not under common cultivation in India are rutabaga (*Brassica napobrassica*), parsnip (*Pastinaca sativa*), and horse-radish (*Armoracia rusticana*).

CHAPTER VIII

Bulb Crops

THE GROUP of bulb crops includes onion, garlic, leek, shallot, Welsh onion and chive. All bulb crops belong to the family Amaryllidaceae and genus *Allium*. Most of them need similar climatic and soil requirements. They are grown in India as winter vegetables. In some regions with a moderate climate, onion can be grown in the rainy season as well. The cultural requirements of all crops belonging to this group are more or less similar.

ONION

(*Allium cepa* L.)
Hindi : *Pyaz*

The onion is one of the most important commercial vegetable crops grown in India. It is grown in north as well as south India. In 1979-80 the area under onion in India was about 2,50,216 hectares. The most important onion-growing States are Maharashtra, Tamil Nadu, Andhra, Bihar and Punjab. Characteristic flavour accounts for its popularity. Onions are used as salad and cooked in various ways in all curries, fried, boiled, baked, used in soup-making, in pickles and for other purposes. This is one of the vegetables which are exported. The nutritive value of onion varies from variety to variety. A general analysis is given below:

Moisture	86.8	g	Protein	1.2	g
Fat	Nil		Minerals	0.4	g
Fibre	0.6	g	Other carbohydrates	11.0	g
Calories	49		Calcium	180	mg
Phosphorus	50	mg	Iron	0.7	mg
Vitamin A	Nil		Thiamine	0.08	mg
Riboflavin	0.01	mg	Nicotinic acid	0.4	mg
Vitamin C	11	mg			

(per 100 g of edible portion)

Small-sized onions are more nutritive. The pungency in onion is due to a volatile oil (allyl propyl disulphide).

History and Taxonomy

The onion originates from the region comprising north-west India, Afghanistan, the Soviet Republics of Tajik and Uzbek, and Western Tien Shan. Western Asia and the area around the Mediterranean Sea are the secondary centres of development. The Welsh onion is probably of Chinese origin. It has been cultivated and used as a food from the earliest period of history. During the great plague of London, the only places immune from contagion were the onion and garlic shops. The onion belongs to the family Amaryllidaceae, genus *Allium* and species *cepa*. The genus *Allium* contains about 300 species, biennials and perennials, mostly bulbous. Some of the wild species produce bulbils instead of seed in the flower cluster. All but a few of the plants of this genus have the characteristic onion odour and flavour.

Varieties

There are large variations in the onion varieties. Onion varieties which are commercially grown are classified into:

Common Onion Group : Common onion

Aggregatum Group : Potato or multiplier onion, ever-ready onion, shallot.

Proliferum Group : Top, tree or Egyptian onion.

The first group is more commonly grown in India. The commercial cultivation of the multiplier onion is very limited. The varieties of common onion are grouped according to their size, colour and pungency. Three most common colours grown are brown to red, yellow and white. The varieties grown are called after the names of the places where they are grown such as **Patna Red, Patna White, Poona Red, Nasik Red, Bellary Red,** etc. The five varieties recommended by the L.A.R.I. are **Early Grano, Pusa Red, Pusa Ratnar, Pusa White Round** and **Pusa White Flat**

Early Grano has been introduced from the U.S.A. and has large globular, yellow bulbs which are mildly pungent and are good for salads.

Pusa Red is a medium-sized, red-coloured onion and keeps well. Pusa Ratnar is a large-sized, high yielding, red-coloured onion. **Arka Kalyar, Arka Niketan** and **Arka Pragati** have been recommended by I.I.H.R. **Agrifound Dark Red** has been selected by A.A.D.F. and **Brown Spanish** is the variety recommended for the hills.

Climatic Requirements

The onion is a cool season crop. Onions are affected by length of day. The requirements of day length of different varieties may differ. Therefore, it is advisable to grow only those varieties which are acclimatised. A relatively high temperature as well as a long photoperiod is essential for bulb formation in most of the commercial varieties grown here. Temperature is more important than the length of day in seed-stalk development. Most of the varieties transplanted early (before November in north India) will form seed-stalk.

In Maharashtra and some other places where the climate is mild, a *kharif* crop is taken. Seedlings of some varieties like N-53 when transplanted in August produce good bulbs in December-January under north Indian conditions.

Soils

Soil for onion should be rich in humus. Onions are grown, however, on all types of soil. The onion is sensitive to high acidity and produces a maximum yield over a fairly narrow range of soil reaction. The optimum pH range is between 5.8 and 6.5.

Manures and Fertilizers

It has been reported that a yield of 30 tonnes of onion per hectare removes 15 kg of nitrogen, 42 kg of phosphate and 130 kg of potash. In the Punjab the dose recommended is 125 kg of nitrogen, 60 kg of phosphate and 100 kg of potash per hectare. Half the dose of nitrogen is to be top-dressed after about a month, the rest of fertilizers being added at the time of transplanting. As Indian soils have a good quantity of potash, the dose can safely be reduced. If available, about 20 tonnes of farmyard manure should be incorporated earlier at the time of preparation of land. The most efficient way of applying fertilizer for onion is to band at five centimetres below the seedlings and two centimetres to the side.

Propagation

The usual method of propagation of common onion is by seed.

Egyptian or tree onions produce top sets or bulbils in the flower cluster. The multiplier or potato onion seldom produces flowers and seed. The small bulb or bottom set grows into a large one which again breaks into small ones.

Sowing Seed

Onion seed is generally sown in the nursery and then the seedlings are transplanted in the field. Direct seeding is also done where labour is costly and transplanting becomes an expensive operation.

In the nursery about 8 to 10 kg of seed is sown for one hectare. One hectare of nursery bed can produce enough seedlings for 20 hectares. In the plains of India for the *rabi* crop, seed is sown from the middle of October to the end of November. For spring onion, seed is sown earlier. In the hills, the seed is sown from March to June.

For direct sowing, about 25 kg of seed per hectare are used and when the plants are six to eight weeks old, they are thinned to proper distance.

Transplanting

The seedlings are transplanted when they are 8 to 10 weeks old. The seedlings are transplanted in December and early January. An earlier-transplanted crop gives a higher yield but the number of bolters may be more. For Delhi conditions end of December to the first of January has been found to be a suitable time. The spacing depends on the variety and size of the bulb. It varies from 10 to 15 cm with space after every 3 to 4 metres, to do intercultural operations.

When bulbs or bulbils are sown, about 1000 to 1200 kg are needed for one hectare. They are dibbled at 15 cm apart in rows at 45 cm.

Weeding and Interculture

Weeds are to be kept down to get a good yield of onion. Onion is a shallow-rooted crop. Any root pruning by cultivation reduces bulb growth. So very shallow cultural operations should always be followed. Chemicals can profitably be used for control of weeds. The most commonly used weedicide is chloro-IPC at the rate of 5 to 6 kg per hectare directed at the base so as not to wet the leaves. Potassium cyanate (450 gm in 60 litres of water) is recommended for killing weeds in onion that are less than two centimetres high. When the onions are taller, a 2 per cent solution of this cyanate can be used. Cyanate should be applied when the weeds are dry and the temperature is 25°C or above. Tenoran at 2.5 kg per hectare in 800 litres of water three weeks after transplanting can also check broad-leaved weeds. Basalin at 1 litre per hectare applied one week after transplanting checks most of the weeds.

Irrigation

The number of irrigation, of course, will depend on several factors such as soil and climatic conditions. The moisture content of the soil should be kept optimum. A dry spell followed by irrigation may cause splitting of the outer scales. Irrigation is stopped when the tops mature and start falling.

Hybrid Vigour

The onion is one of the vegetables where commercial production of F_1 hybrid seeds has been taken up in a number of agriculturally advanced countries. The standard varieties are being replaced by F_1 hybrids. These hybrids not only give higher yields but also are more uniform and better in other qualities. For economic production of hybrid seeds, male-sterile lines are used as female parents.

Harvesting

Green Bunch Onions : Green onions are best when they are of the diameter of a lead pencil and until a small bulb is formed.

Ripe Bulbs : A well-matured bulb should be harvested. Maturity is indicated by the tops drooping just above the bulb while the leaves are still green. If the bulbs are mature they are pulled out easily by hand if the soil is not hard or compact; otherwise, they may be dug out with a shovel or *khurpi*.

Yield

25 to 30 tonnes per hectare. The yield of *kharif* crop is comparatively low.

Curing

Onion bulbs that are to be stored in crates are usually thoroughly cured before being placed in storage. The length of time required for curing depends largely on the weather conditions and thorough curing requires three or four weeks.

Cleaning and Grading

After curing, onions are cleaned of dirt and graded. All open necks, bottle necks and injured bulbs are rejected. The Indian Standards Institution has fixed three grades for onions in India.

Storage

Onions should be thoroughly matured, cured and dried before being stored. The essentials of successful storage are thorough ventilation, a uniform and comparatively low temperature, low humidity, proper maturity and freedom from disease infection. The best storage temperature is about 0°C. The most common modes of decay are gray-mould rot and sprouting. A low humidity of 60-75 per cent largely prevents root growth and checks spread of rot but increases the rate of shrivelling. High humidity is suitable, provided the temperature is kept at 0°C. Shrinkage from sprouting, rotting and other causes under favourable storage conditions may be 7-15 per cent, depending on the variety. Preharvest foliage sprays of maleic hydrazide (MH 40) may be helpful in controlling the sprouting of onions in storage. A spray with 2500 parts per million of MH 40 applied shortly before the tops are down greatly retards sprouting. However, doubts have now been expressed on the residual toxic health hazard effects of MH. Irradiation of harvested bulbs is safer for inhibiting sprouting. *Kharif* crops do not store well.

Seed Production

The onion is mainly a cross-pollinated crop. Its flower is pollinated by honeybees. Two methods are employed in the production of onion seed. The one used most commonly is the bulb-to-seed method, which involves first producing bulbs as for the market and then replanting them for seed production. While a smaller volume of seed is produced by the seed-to-seed method, generally medium-sized bulbs are selected for planting for seed. The bigger the bulb size, the higher is the seed yield. However, very large-sized bulbs if used will need a very high seed rate. A bulb size of 2.5 to 3 cm diameter may need 1500 kg to plant a hectare and may yield about 850 kg of seed. Large size bulbs of 3 to 4 cm diameter will need three times more seed bulb and may yield 1000 kg of seed per hectare. Bulbs are planted by the first fortnight of October. The spacing depends on the size of bulbs. A closer spacing of 30 cm within rows gives higher yield of seed than when the bulbs are planted at 45 cm for the variety Pusa Red. The spacing between rows is kept at 45 cm. The spacing is kept more for the variety Early Grano.

There are some varieties which do not store well or sometimes someone wants to get the seed within the same year. In such cases the seed-to-seed method is practised. The seeds are sown in August and the seedlings are transplanted in September. Most of the bulbs give out flowering stalks and form seeds.

For nucleus and foundation seed production, the bulb-to-seed method should be followed. The storing and transplanting of bulbs provide an opportunity for selection and roguing. However, the seed-to-seed method may produce a higher quantity of seed.

Diseases

The onion crop is subject to a number of diseases. The more important diseases prevailing in India are briefly described below:
Downy Mildew: This disease is caused by a fungus known as *Peronospora destructor* and is chiefly confined to areas having a high humidity. A violet furry growth on the surface of the leaf or seed stem is the first characteristic symptom. The stalk when attacked may become weakened and break from the weight of the umbel. Sprays with cuprous oxide plus rosin soap, rosin lime-sulphur or Bordeaux mixture plus cotton seed oil control the disease. Varietal differences exist in the degree of susceptibility.
Purple Blotch: This fungus, *Alternaria porri* attacks its leaves, seed stems, and bulbs. It appears as small, whitish sunken lesions with purple centres that rapidly enlarge. The leaves or seed stems fall down from the point of attack and die.
Onion Smut: This fungus disease caused by *Urocystis cepulae* is important where temperatures remain below 30° C. Therefore, it is generally not a problem in the plains of India. Treating the seeds with Arasan or Tersan can sufficiently check the disease.
Bacterial and Fusarium Rots: These attack onions in storage.

Bacterial or soft rot gives out a foul odour and Fusarium rot is a semiwatery rot from the base of the scale upwards. Black mold caused by *Aspergillus niger* is the most common storage disease of onion bulb. Rapid and thorough curing and good ventilation and storage temperatures just above 0° C are important measures to control the disease.

Aster Yellow is a virus disease. The onion inflorescence when affected becomes abnormal in appearance.

Insect Pests

Onions Thrips are the most important insect. They are very small and yellow. They cause whitish blotches on the leaves and the tips turn brown and die. Repeated dusting or spraying with Rogor can control the insect.

Onion Maggots are the larvae of a small grey fly which resemble those of the housefly but are smaller. The eggs are laid in the soil near the base of the plant and hatch in one week. Spraying the soil around the base of the plant with a 4 : 4 : 50 Bordeaux mixture containing 2 per cent lubricating-oil emulsion has proved effective in controlling the insects. This treatment should be repeated every week or every ten days. Use of Aldrin or Dieldrin also ensures good control.

GARLIC

(*Allium sativum* L.)

Hindi : *Lahsan*

Garlic is an important crop grown and used as a spice or condiment throughout India. This crop is another foreign exchange earner for India as a good quantity of garlic is exported every year. A compound bulb contains the edible product of this crop. The group of small segments or cloves is surrounded by a thin white or pinkish sheath. The flavour of the cloves is more powerful than that of the other bulb crops. The foliage is flattened rather than hollow like that of the onion. It has a higher nutritive value than other bulb crops and its preparations are administered as a cure against some long and lingering stomach diseases and sore eyes and ear-ache. The nutritive value of dry garlic is as follows:

(per 100 g of edible portion)

Moisture	62.0 g	Phosphorus	310 mg
Protein	6.3 g	Iron	1.3 mg
Fat	0.1 g	Vitamin A	0 I.U.
Minerals	1.0 g	Thiamine	0.16 mg
Fibre	0.8 g	Riboflavin	0.23 mg
Other carbohydrates	29.0 g	Nicotinic acid	0.4 mg
Calories	142	Vitamin C	13 mg
Calcium	30 mg		

History, Taxonomy and Varieties

The history of garlic, like that of onion, dates back to time immemorial. Central Asia is the prime origin and the Mediterranean area is a secondary centre. It belongs to the family Amaryllidaceae, genus *Allium* and species *sativum*.

There are hardly any recognised varieties in India. Creole, Italian and Tahiti are some of the varieties grown in foreign countries. The Indian varieties can be grouped into two small to medium-sized bulbs with small and large number of cloves and big-sized bulbs and cloves. The latter varieties are commonly grown on the hills.

Climatic Requirements

Garlic grows well in places where onions grow but performs better where the summer and winter temperatures are moderate. It is generally grown as a cool season crop in India.

Soil and Manurial Requirements

The soil requirements are the same as those for onion except that garlic needs a richer soil than onion. The main requirement is that of nitrogen. About 125 to 150 kg of nitrogen per hectare should be applied in two doses for best results.

Seed Rate and Sowing

Garlic is propagated by cloves which are detached individually from the bulb. About 350 to 500 kg of cloves are required to plant one hectare. For highest yield the cloves are dibbled at a spacing of 15 cm from row to row and 7.5 cm within the rows. The field is divided into small plots to facilitate proper irrigation. The crop is sown from September to November in the plains of northern India.

Harvesting

The crop gets ready for harvest when the top turns yellow to brownish. The bulbs are cut, cleaned and then cured for four to five days in shade.

Yield

After removing the tops, the yield per hectare may vary from 4,000 kg to 10,000 kg, depending on the soil, variety and care taken.

Diseases and Insect Pests

They are mostly the same as those of onion.

LEEK

(Allium porrum L.)

Leek is a non-bulb-forming member of the onion family and is grown for its blanched stem and leaves. It is eaten raw alone or mixed in salads and cooked as flavouring in soups and stews. It is not grown in India on a commercial scale but is a favourite vegetable in a kitchen garden. The nutritive value of leek is as follows:

(per 100 g of edible portion)

Moisture	78.9 g	Calories	77
Protein	1.8 g	Calcium	50 mg
Fat	0.1 g	Phosphorus	70 mg
Minerals	0.7 g	Iron	2.3 mg
Fibre	1.3 g	Vitamin A	30 I.U.
Other carbohydrates	17.2 g	Thiamine	0.23 mg
		Vitamin C	11 mg

The leek is believed to have originated in the Mediterranean region. It belongs to the family Amaryllidaceae, genus *Allium* and species *porrum*. The most common varieties are **London Flag** and **American Flag**. The climatic and soil requirements are the same as those for onion.

The seeds are sown in the nursery earlier than for onion, sometime from the end of September to October. The method of transplanting is often the same as that for onion except that greater spacing is maintained. The plants are often blanched by earthing it up with soil. The transplanting is done in trenches about 30 to 45 cm deep. The soil is worked up to the plants gradually as they grow, care being taken not to start this process too early when the plants are young.

The plants of leek being larger than those of onion, the requirements of manures and fertilizers are higher. A yield of 30 tonnes of leek per hectare removes 100 kg of nitrogen, 65 kg of phosphate and 130 kg of potash from the soil.

The leek is a biennial crop and the seed is produced in India at higher altitudes in the hills. The diseases and insect pests are the same as those of onion.

Other crops in this group are cibol (ciboule) or Welsh onion (*Allium fistulosum* L.), shallot (*Allium ascalonicum* L.) and chive (*Allium schoenoprasum* L.).

CHAPTER IX

Beans

THERE ARE at least eighteen types of cultivated beans. All belong to the same family Leguminosae and cover about eight different genera. Beans may be used as green vegetables, 'green-shelled' or dry as pulses, according to the stage at which they are harvested. The different types of beans vary greatly in flavour, season and other characteristics. From the green vegetable stand point, French beans, cowpea and *sem* are the most important. Varieties used for this purpose have somewhat fleshier-walled pods with less fibre in the younger stages. The dry bean industry is an important source of food and beans are classed usually as a field crop. All beans except broad beans are susceptible to frost and are grown as a summer crop.

FRENCH BEAN OR KIDNEY BEAN

(Phaseolus vulgaris L.*)*

Hindi : *Farash bean*

Of all the beans, French bean is most extensively grown as green vegetable. In India, nearly six thousand hectares annually produce 12,50,000 tonnes of beans. Dry (field) and green (garden) beans rank high as a cheap source of nourishing food. They are a valuable source of protein, calcium, iron and vitamins. A nutritive analysis of French bean is given below:

(per 100 g of edible portion)

Moisture	91.4 g	Protein	1.7 g
Fat	0.1 g	Minerals	0.5 g
Fibre	1.8 g	Other carbohydrates	4.5 g

Calories	26		Calcium	50	mg
Phosphorus	28	mg	Magnesium	29	mg
Sodium	4.3	mg	Iron	1.7	mg
Copper	0.21	mg	Potassium	120	mg
Vitamin A	221	I.U	Sulphur	37	mg
Riboflavin	0.06	mg	Thiamine	0.08	mg
Vitamin C	14	mg	Nicotinic acid	0.3	mg

History and Taxonomy

The French bean is probably a native of South and Central America and undoubtedly is of ancient origin. When white men reached America, they found the Red Indian cultivating the beans along with maize and that the beans supplemented their maize diet. Spanish explorers were perhaps the first to introduce it into Europe. From Europe, it spread to Africa, the East Indies, India and other parts of the world.

It belongs to the family Leguminosae, genus *Phaseolus* and species *vulgaris*. Generally, three types of kidney beans are recognised by their habits. The dwarf bush type has a short, erect stem with the main axis consisting of 4 to 8 shortened internodes. The semi-pole or summer type has from 4 to 8 internodes which are longer than those in the bush type. The pole type has longer internodes and their number is dependent upon the length of the growing season.

Varieties

French bean varieties are first grouped into two: bush and pole types. Within each group the varieties are classified according to their pod characters, whether the pods are green, yellow or purple, flat, oval or round. There are a large number of cultivated varieties. Among the bush varieties are:

Contender— a disease-tolerant, green, round-podded, prolific variety.

Giant Stringless, Tendergreen, Pusa Parvati, Arka Komal—green, round-podded, prolific varieties.

Among the pole types **Kentucky Wonder** is most commonly grown.

Climatic Requirements

The different beans can be classified into long-day, short-day and day-neutral plants. Most of the French bean varieties are day-neutrals, that is, the length of the day does not materially affect their seedling habit, except some semi-pole varieties which are short-day. The kidney bean is sensitive both to frost and to very high temperatures. The seed will not germinate in cold soil. The plants drop their blossoms or pods in very hot or rainy weather. Best pod-set is obtained with plants kept at 15° C to 25° C for four hours after pollination.

Soil and Manurial Requirements

Beans are grown on practically all types of soil from light sand to heavy clay. They do not do well on extremely acid soils. The highest yield is obtained between pH 5.3 and 6.0. Bean is a legume, and as such only phosphatic and potassic fertilizers are generally recommended. But it is a vigorous legume and makes such rapid growth that often a nitrogenous fertilizer gives a good response. Twenty-five to fifty tonnes of farmyard manure per hectare should be applied at the time of preparation of land. It is estimated that a yield of 800 kg of grain and 700 kg of straw removes 73.5 kg of nitrogen, 31 kg of phosphate and 61 kg of potash from the soil. For best results, application of 250 kg of ammonium sulphate, 500 kg of single superphosphate and 125 kg of potassium sulphate, or muriate of potash per hectare is recommended. The fertilizers should be placed in bands about 7 to 8 cm to the side of the seed and slightly deeper than the seed. Among the minor elements, magnesium and zinc enhance the vitamin C content. A deficiency of calcium and magnesium results in a lower protein content. It has also been reported that spraying with each of the trace elements, Mg, Fe, Zn, Cu and Ni, produces a higher quality and increased yields.

Sowing Time and Seed Rate

In the plains of India, there are two seasons for sowing beans. The first sowing is done in July to September and the second in early spring, that is, January-February. In the hilly regions, the sowing is done from March to the beginning of May. The seeds germinate slowly at a soil temperature of about 15° C, and at a lower temperature they may rot in the ground. The seed rate of beans varies considerably, depending on the variety grown, soil and climatic conditions. The seed rate for the bush variety may be about 85 to 90 kg per hectare. The rate for pole varieties is lower and is about 25 to 30 kg per hectare. The row-to-row spacing for bush beans varies from 60 to 70 cm. Pole beans are often sown in hills about one metre apart. About half a dozen seeds are sown in each hill and later are thinned to 3 or 4 plants. In parts of the U.S.A., pole beans are trained on a trellis and the row-to-row distance is kept at about 1.5 to 2 metres. In most parts of India where pole bean is grown, staking is done on poles or dry branches of plants.

Inoculation

If beans are being sown in a field for the first time, it is advisable to inoculate the seed with nitrogen-fixing bacteria before sowing. This helps in quick nodulation on the roots, which fix atmospheric nitrogen.

Weed Control

Hand-hoeing is often necessary to control weeds. In the U.S.A. and other agriculturally advanced countries, commercial bean-growers use chemical herbicides. Di-nitro materials are sprayed on the soil at the rate of 5 to 8 kg per hectare. The other chemical which is also effective as a pre-emergence weedicide is the sodium salt of pentachlorophenol applied at the rate of 45 kg per hectare.

Irrigation

Beans are shallow-rooted and sensitive to an over supply of water. Good crops can be produced with very little moisture applied during the season. Application of water just prior to blooming, however, helps in setting pods and another irrigation should be given soon after these have set. An additional irrigation is given when needed. It is essential to maintain available soil moisture above 50 per cent during flowering and pod development.

Use of Plant Regulators for Fruit-Set

In beans the success of pollination, fertilization and fruit-set depends on the prevailing weather conditions. Certain plant regulators like para-chlorophenoxyacetic acid at 2 ppm, alphanaphthyl-acetamide or beta-naphthoxyacetic acid at 5 to 25 ppm when sprayed at prevailing temperatures, when normally pods do not set, induce fruit-set. Thus by spraying some plant regulators, higher, early and total yields can be obtained.

Harvesting

Green pods are usually harvested before they are full grown and while the seeds are small. Pods are usually ready for harvest 2-3 weeks after the first blossom. As harvest is delayed, the total yield increases but the quality falls rapidly. Picking is usually done by hand. Mechanical pickers have been developed in advanced agricultural countries. Most growers make the first picking by hand and then use the machine for the final picking. Pole beans bear over a longer period than bush beans.

Dry beans are harvested when a large percentage of pods are fully ripe and most of the remainder have turned yellow. Harvesting should be started before the lower pods become dry enough to shatter. Harvesting is done either by hand or by machine. Beans require one to two weeks to cure, after which they are threshed either by bullock or by machine. Care should be taken so that seeds are not injured even internally at the time of machine-threshing and cleaning.

Seed Production

Bean flowers are principally self-pollinated. Natural crossing, however, is more common than in the case of peas. The percentage of cross-pollination may vary from 2 to 8 per cent. Mechanical mixtures of varieties at the time of threshing, cleaning and storing should be avoided.

Yield

Yields of beans vary considerably with the area, fertility of soil and the variety. The yield of green pods in the bush varieties may vary on an average from 3000 to 4000 kg and the pole varieties from 7 to 10 tonnes per hectare. The yield of dry beans or bean seeds varies from 1200 to 1800 kg per hectare.

Diseases

The production of beans is greatly reduced every year by fungus, bacterial and virus diseases. Some of the important diseases and their possible control measures are given below:

Anthracnose: This disease is caused by a fungus, *Colletotrichum lindemuthianum*. The disease is likely to be serious only when the weather is moderately cool, humid, or rainy during the growing period. The organism produces yellowish to brown sunken cankers. The lesions vary in size. Diseased seeds carry the fungus from season to season. Seed treatment for half an hour in a 0.125 per cent solution of ceresan is often effective. Spraying the crop with any copper fungicide and long crop rotations can also control the disease. Use of resistant varieties like **Tweed Wonder** is also recommended.

Powdery Mildew: This fungus, *Erysiphe polygoni* attacks all parts of the plants except the roots. It first attacks the leaves and spreads later to the stem and pods. The symptoms are slightly dark areas on the leaf, which later turn into small, white powdery spots that enlarge and combine with others to form eventually an almost complete coating of a whitish powder. In severe cases defoliation occurs. The disease can be controlled by dusting sulphur or sulphur-lime. Application should begin at the first appearance of the disease and should be repeated thereafter every 10 to 15 days, if needed. Use of resistant of less susceptible varieties is also recommended.

Rust: Bean rust has been reported from most parts of the world having a high relative humidity and is caused by *Uromyces phaseoli typica*. The symptoms usually appear first on the lower surface of leaves in the form of minute, almost white, slightly raised spots. These gradually become dark brown to black. Finely ground sulphur at the rate of 25 to 30 kg per hectare, if dusted even before the infection, protects the crop. Rust-resistant varieties should be used in areas where the disease is prevalent.

Ashy Stem Blight: This fungal disease due to *Macrophomina phaseoli* causes black, sunken canker on seedlings. A small dark, sunken lesion on the stem is the first evidence of the disease. The lesion spreads very rapidly and the entire stem may be attached, often killing the growing point. The disease is seed-borne. So disease-free seed is the primary method for control of the disease. Dusting the seed with 2 per cent ceresan effectively controls the infection.

Common blight: is a bacterial disease caused by *Xanthomonas phaseoli*. The first symptoms are small water-soaked spots on the underside of the leaf that enlarge and coalesce with similar infected areas. The leaves turn brown giving the appearance of a burning effect. Infection on pod may occur at any place as small water-soaked spots that gradually enlarge. The disease is seed-borne. Insects like grass-hoppers and Mexican bean beetle have been reported to spread the disease from plant to plant. The disease remains in the soil on which a diseased crop has grown, in the straw from infected fields, and in bedding or manure.

Use of disease-free seed, long rotation and use of resistant varieties are the control measures.

Common Bean Mosaic: This is the most serious virus disease of bean though it rarely kills the plant. It stunts the plants and causes mottling and various types of leaf malformation. The disease is transmitted by seeds, mechanically and through insects. The main insect vectors are the different species of *Aphis*. The only satisfactory method of control is the use of resistant varieties. A number of bean varieties have been found to be resistant.

Other important virus diseases of beans are yellow bean mosaic and curly top. There are varieties which have combined resistance or tolerance to several strains of virus diseases, but no variety has yet been reported to be resistant to yellow bean mosaic.

Root Knot Nematodes: Beans of all kinds, with the exception of a few varieties, are highly susceptible to the attack of root-knot nematodes. Losses even upto 50 per cent of the crop are possible in a heavily infected soil. The attacked plants are pale and yellowish, somewhat dwarfed, and have a tendency to wilt during the warmer part of the day. The roots show typical galls ranging from pinhead size to 2 cm or more in diameter. These galls should not be confused with the bacterial nodules. These galls cannot be detached from the roots, whereas the nodules formed by nitrogen-fixing bacteria are loosely attached to the side of the root.

There are three methods of control: (1) by soil fumigation with different nematicides, like DD or Nemagon, (2) by long crop rotation, and (3) by growing resistant varieties.

In addition to these, the bean crop may suffer from different non-parasitic diseases due to physiological disorders. These may be mainly due to different nutritional deficiencies or toxicity.

Insect Pests

Many insects attack the bean, the most important being bean beetle, bean weevil, bean thrips and bean aphid.

Bean Beetle: The adult is a copper-coloured, hard-shelled beetle with 16 black spots on its back. Both the adult and the larva are injurious and feed on all parts of the plant. The control measures consist of spraying with 4 per cent rotenone at the rate of about 1.5 kg in 450 litres of water. Cryolite at the rate of 1.5 kg in 225 litres of water, Sevin and malathion have also been effectively used. The first application should be made as soon as any insects appear. Further applications are made as and when needed.

Bean Weevil: This is a small dull-coloured beetle found in stored seed beans. The beans may become infested either in the field or in storage or in both places. The eggs may be laid in the pods or in the field, and the grubs develop in the seeds and get transformed into beetles. They cut a circular opening through the seed coat while emerging. The weevils in the beans can be killed by fumigating with carbon disulphide at the rate of 1.5 to 4 kg to each 30 cubic metre of space to be fumigated. For best results the temperature should be 25° C or above. Three per cent DDT dust can be mixed with the seed before storage, but this should be used only on seed and not on those which are to be eaten later.

Bean Aphid: The aphids may be controlled by spraying with parathion, malathion or nicotine sulphate.

Bean Thrips: The adult is small and greyish in colour. Infested leaves turn pale and drop. Pods after infestation take on a silvery white appearance. A thorough spraying with DDT or Rogor if done in the initial stages of attack may completely control the pest.

Seed-corn Maggot: This maggot attacks the germinating seed or seedling in the soil. It may completely destroy the seedling or it may damage it, thereby causing a reduction in the yield. The adult fly is somewhat smaller than the housefly and is greenish-grey in colour. The larva is a white maggot. The common control measure is to coat the seed with an insecticide, such as chlordane, lindane or aldrin applied as a slurry. Land in which organic manures have not well decomposed should be avoided for sowing bean.

HYACINTH BEAN

[*Dolichos lablab* (Roxb.) & L.]

Hindi : *Sem*

The common bean is one of the most ancient among cultivated plants. It is called in western countries *Bonavist*. It is a field crop in Tamil Nadu, Andhra Pradesh, Madhya Pradesh and Maharashtra. The garden varieties are rare in northern India but common in other parts of India. This bean is used both as a green vegetable and as a pulse crop. It is richer than the French bean in its nutritive value. Its food value is given below.

(per 100 g of edible portion)

Moisture	86.1	g	Protein	3.8	g
Fat	0.7	g	Minerals	0.9	g
Fibre	1.8	g			
Calories	48		Other carbohydrates	6.7	g
Calcium	210	mg	Oxalic acid	1	mg
Magnesium	34	mg	Iron	1.7	mg
Phosphorus	68	mg	Potassium	74	mg
Sodium	55.4	mg	Sulphur	40	mg
Copper	0.13	mg	Thiamine	0.1	mg
Vitamin A	312	I.U.	Nicotinic acid	0.7	mg
Riboflavin	0.06	mg	Vitamin C	9	mg

History and Taxonomy

Wild forms of this bean are found in India and this country is probably the place of its origin. From India it is likely that it was introduced into China, Western Asia and Egypt. This belongs to the family Leguminosae. Its scientific name is *Dolichos lablab*. *Dolichos* in Greek means long pod; *lablab* is an Arabic or Egyptian name describing the dull rattle of the seed inside the dry pod.

Varieties

Very little work has been done on the study of the varietal characters of beans. There is a great range of varieties with different plants and pod characters grown all over the country.

There are broadly two groups, the bushy field variety and the twining-pole garden variety. The variety recommended by the I.A.R.I. is **Pusa Early Prolific.** It bears early long thin pods in bunches and is suitable for sowing as both early spring and autumn crops.

Sowing and Cultivation

Field varieties are sown with the advent of the monsoon in July-August, come into flower in November-December and are harvested in January-February in frost-free areas. In central and south India this bean is grown either pure or mixed with sorghum with which it forms a common mixture in the red loams of Coimbatore. It is drilled at intervals among the sorghum and when the earheads are cut, late as the bean is, it twines on the sorghum stalks, flowers profusely and gives a crop of both green and dry pods. Its vines when cut with sorghum straw give a mixed feed of good fodder value.

Other cultural operations, diseases and pests are nearly the same as for French bean. It gives a yield of 3,000 to 5,000 kg of green pods per hectare.

COWPEA

(*Vigna sinensis* Savi.)

Hindi : *Lobia*

This is another bean which has long thin pods and is commonly grown throughout India. Like all other leguminous crops, it is also consumed both as green pod and dry seed and is rich in nutritive value. The nutritive analysis of cowpea (purplish) is given below:

(per 100 g of edible portion)

Moisture	84.6	g	Minerals	0.9	g
Protein	4.3	g	Other carbohydrates	8.0	g
Fat	0.2	g	Calcium	80	mg
Fibre	2.0	g	Iron	2.5	mg
Calories	51		Thiamine	0.07	mg
Phosphorus	74	mg	Nicotinic acid	0.9	mg
Vitamin A	941	I.U.	Vitamin C	14	mg
Riboflavin	0.09	mg			

It is probably a native of Central Africa. Cultivated cowpeas consist of three main groups : the asparagus bean or yard long bean *(Vigna sinensis* var. *sesquipedalis)*, the catjung *(V. sinensis* var. *cylindrica* or *V. unguiculata* and the southern pea.

Different varieties respond differently to temperature and day-length. The rainy season variety, if sown in summer, may give only vegetative growth. The three varieties recommended by the I.A.R.I. are:

(i) **Pusa Phalguni** (for spring sowing) plants dwarf and bushy, pods ready in about 60 days, pods deep green, about 10 to 12 cm long.

(ii) **Pusa Barsati** (for rainy season sowing) plants dwarf, pods 20 to 25 cm long, light green in colour, become ready in about 45 days.

(iii) **Pusa Dofasli** (for both seasons) is an improvement over the pod quality of Pusa Phalguni, in that it retains the desirable attribute of not being season-bound. Plants are bushy with pods 18 cm long and are suitable for both plains and hills. The variety flowers in about 40 days.

Pusa Phalguni is sown in February-March and about 20 kg of seed are sown per hectare. Pusa Barsati is sown in June-July and about 12.5 kg of seed are required for a hectare.

(iv) **Pusa Komal** : is suitable for both summer and rainy seasons.

The pod-set in both the varieties can be increased by about 35 per cent by giving a spray of maleic hydrazide at 15 ppm just before the flowering stage. This suppresses apical dominance, forces more lateral shoots, makes the plants more bushy and produces more pods per plant.

Other cultural operation for diseases and pests are the same as for beans. It yields about 5000 kg to 6000 kg of green pods per hectare.

LIMA BEAN

(Phaseolus lunatus L.)

Green lima bean is grown for home use, for fresh markets, and for canning and freezing in various parts of the U.S.A., Canada and Latin America. This bean though of high nutritive value is not commonly grown in India. Lima bean is not cross-compatible with French bean. The requirements of both these beans are similar.

The lima bean originated in or near Guatemala. The varieties are generally grouped as pole types, semi-pole and bush or dwarf types.

Among the pole type **Florida Butter** and **Challenge** and among the semi-pole type **Hopi** and **Wilbur** and in the bush type **Burpee Bush, Fordhook 242** and **Henderson Bush** are the important varieties.

The cultural operations are the same as those for French beans. Lima bean is less susceptible to diseases and pests as compared to French bean. This bean has got a good future in India and is worth trying in different parts.

CLUSTER BEAN

(*Cyamopsis tetragonoloba* L. Taub.)
Hindi : *Guar*

The cluster bean is cultivated in many parts of India and is grown for green vegetable, dry seeds and also as a forage crop. It is also used as a green manuring crop. Some of its varieties are used for extraction of gum. Its green pods are as rich in food value as French beans and noted for their resistance to drought.

It is essentially a warm season crop and is generally planted twice, in spring and in the rainy season.

The cluster bean belongs to the family Leguminosae, genus *Cyamopsis* and species *tetragonoloba*.

There are a number of varieties, some suitable as a green manuring or forage crop and others for green pods.

Some varieties are weather-bound and do well in particular seasons. Such is the variety **Pusa Mausami**. This variety is suitable for growing only as a rainy season crop, whereas there are other varieties like **Pusa Sadabahar**, which are suitable for sowing both as a summer crop and a rainy season crop. **Pusa Naubahar**, is the latest released variety from the I.A.R.I., and is suitable for sowing in both seasons.

The crop is sown in rows 45 to 60 cm apart and the spacing from plant to plant is kept from 20 to 30 cm.

The yield of green pods varies from 5000 to 8000 kg per hectare.

The most serious disease of cluster beans is bacterial blight caused by *Xanthomonas cyamopsidicola*. This is more common in irrigated and humid tracts. The blight appears as very small translucent, water-soaked spots on leaves. The interveinal tissues turn yellow and die to form dead tissues of various sizes and shapes. With the progress of the disease, brownish discoloration of the vascular system becomes evident on the stems and the plant may break at this point. The disease is carried through seed and soil. The control measures therefore are to use seeds from disease-free plants, to follow long rotation and if possible to use a disease resistant variety.

BROAD BEAN

(*Vicia faba* L.)

The broad bean is a hardy plant and is the only bean which can withstand sufficiently cold temperatures. This is a native of Europe and Asia. This is the only bean which is sown in the autumn and is grown as a winter crop. This is an important food crop in South America. This bean as the only winter legume should be more popularised. The seeds are planted in rows about 45 to 60 cm apart. About 70 to 100 kg of seed are needed to plant one hectare.

The plants, which belong to the family Leguminosae, genus *Vicia* and species *faba*, are 60 to 100 cm tall. They bear numerous initially upright pods in the axils of the leaves along the stem. At market maturity, the green pods are slightly rounded about two cm in width and 15 cm or more in length. Each cluster contains five or more fleshy beans.

There is no improved variety available in India but several exotic varieties introduced from abroad are grown.

Some people are allergic to the pollen of this plant and also to the green pods. An illness sometimes fatal and known as "favism" is caused. The insect pests and diseases are the same as for other leguminous crops.

WINGED BEAN

(*Psophocarpus tetragonolobus* (L.) D.C.)

The winged bean, also known as four angled bean and Goa bean is a tropical legume of exceptionally high value. It produces edible pods, seeds, leaves, flowers, tuberous roots and edible seed oil.

The winged bean, which has originated in Papua New Guinea and Southeast Asia, is cultivated for its young tender pods, which are sliced and cooked. They contain 1.9 to 2.9 per cent protein. The young leaves and shoots are sometimes eaten as leafy vegetable and contain 6 to 15 per cent protein. Unripe seeds can also be cooked. The nutritive value of the ripe, dry seeds is very high. They contain 34 per cent of protein having high lysine and 18 per cent of oil. The immature tuberous roots are eaten like potatoes. They contain over 12 to 15 per cent protein.

The winged bean, a climbing, herbaceous perennial, can reach heights of 3-4 m, if supported. It is cultivated from the sea level upto 2,000 m but prefers humid tropical climate. Despite its perennial nature it does not survive prolonged drought. It is photosensitive and requires short day for normal flower induction.

The seeds are sown by the beginning of rainy season. The staked plants take about 50 days to flower. The first green pods are ready for picking about 10 weeks after sowing. To grow large tubers plants are spaced 10-20 cm apart. The tubers are harvested 4-8 months after sowing when they reach 2-4 cm in diameter and 8-12 cm in length. The seed yield is about 1.5 tonnes per hectare, whereas, the tuber yield may vary from 600 to 1200 kg per ha. In Papua New Guinea and Burma whenever the crop is grown only for tuber, yields exceeding 4.0 tonnes per hectare have been reported. This vegetable should be more widely grown in southern and eastern India.

OTHER BEANS

SOY BEAN

(Glycine max L.)

This is a native of Southeast Asia and has been cultivated in Japan, China and India since ancient times. This is cultivated for soy bean milk and oil. A scheme for improvement and spreading the cultivation of this nutritious crop has been recently started.

Other beans which are cultivated and used as green pods, though on a very limited scale are scarlet runner, or multiflora bean (*Phaseolus coccineus*), tepary bean (*P. acutifolius*), velvet bean (*Stizolobium Deeringianum*) and sword bean (*Canavalia ensiformis* or *gladiata*).

CHAPTER X

Peas

(Pisum sativum L.)
Hindi : *Matar*

PEAS OCCUPY a position of considerable value because of its importance in the agricultural economy of the country. The importance of peas as a pulse and as a vegetable crop in human diet needs no emphasis. Peas are highly nutritive and contain a high percentage of digestible protein, along with carbohydrates and vitamins. Besides, they contain a higher proportion of mineral matter. It is an excellent food for human consumption taken either as a vegetable or in soup, canned, frozen or dehydrated Pea-straw, when harvested in a sound condition, is a nutritious fodder. The nutritive analysis of peas is as follows:

(per 100 g of edible portion)

Moisture	72.0	g	**Protein**	7.2	g
Fat	0.1	g	**Minerals**	0.8	g
Fibre	4.0	g	**Other carbohydrates**	15.8	g
Calories	93		**Calcium**	20	mg
Magnesium	34	mg	**Oxalic acid**	14	mg
Phosphorus	139	mg	**Iron**	1.5	mg
Sodium	7.8	mg	**Potassium**	79	mg
Copper	0.23	mg	**Sulphur**	95	mg
Vitamin A	139	I.U.	**Thiamine**	0.25	mg
Riboflavin	0.01	mg	**Nicotinic acid**	0.8	mg
			Vitamin C	9	mg

History and Taxonomy

The pea is one of the crops which were cultivated in the ancient period. Its origin can be traced back to the Stone Age. Ethiopia is probably the main centre of origin of the garden peas. The peas belong to the family Leguminosae. The garden pea is grouped as *Pisum sativum* subsp. *hortense* and the field pea as *P. sativum* subsp. *arvense*. Edible podded peas are found in both these subspecies.

Varieties

Garden pea varieties are grouped into two, smooth-seeded and wrinkle-seeded. The wrinkle-seeded varieties are sweeter. In agriculturally advanced countries, the pea varieties are first grouped as home and market garden and then varieties suitable for canning, freezing or dehydration. Each group has early, mid-season and late varieties divided according to their period of maturity. The varieties recommended by the I.A.R.I. are:

Early: **Asauji** and **Meteor:** smooth-seeded varieties suitable for early sowing, take 60 to 65 days to be ready for green pod harvest.

Early Badger: a wrinkle-seeded, dwarf variety, takes 65 days to be ready.

Arkel: a wrinkle seeded high yielding dwarf variety, takes 60 days to be ready for green pod harvest.

Mid-season: **Bonneville:** wrinkle-seeded, double podded, medium tall variety, takes 85 days.

Late: **N.P. 29:** plants tall, wrinkle-seeded and takes about 100 days.

Edible podded: **Sylvia:** tall growing variety, pods soft without any parchment layer, curved, good cropper.

Varieties suitable for Hills

Early Giant: early, plants tall, dark green pods with wrinkled seed.

Alderman: early, plants tall, pods more or less straight,. nearly nine centimetres in length.

The variety Lincoln performs will in the hills. Other varieties recommended and distributed by other States and organisations: National Seeds Corporation—**New Line Perfection;** U.P.—**T19** (wrinkle-seeded) and **T17** (Smooth-seeded); Punjab—**P8, P35, Marrow Fat, Thomas Laxton, Telephone,** etc.; Madhya Pradesh —**Jawahar 1, Jawahar 2, Jawahar 3** and **Jawahar 4.**

Climatic Requirements

Garden peas thrive best in a relatively cool weather. In contrast to beans, peas are able to withstand relatively low temperatures especially during the seedling stage. The plants, however, may not withstand a severe continued frost. The flowers and young pods are badly affected by frost. Hot dry weather interferes with the setting of seed and lowers the quality of pods produced. Peas grow best in those sections where there is a slow transition from cool to warm weather in the spring. The seeds can germinate at a minimum temperature of 5°C and the optimum temperature for germination is about 22°C. At higher temperatures, while the germination is rapid, loss of stand may result from various decaying organisms.

Soil and Soil Preparation

Garden peas can be grown on a variety of soils from light sandy loam to clay, though best results are obtained on well-drained, loose, friable, loamy soils. They do not perform well on acidic soils and will not do well if the pH falls below 5.5. The most favourable range of pH is between 6.0 and 7.5 and if it falls below 6.0, the land should receive adequate, though not excessive, dressing of lime. A thorough preparation of soil is necessary. The surface should be smooth and free from clods, so that no difficulty arises at the time of sowing. It is necessary to sow all seeds at the same depth. Uneven germination of the seed results in wide variation in maturity of peas at harvest time.

Sowing Time and Seed Rate

In the plains of northern India, most of the varieties are suitable for sowing from the beginning of October to the middle of November. Seeds sown earlier are very much susceptible to a number of rotting organisms. These organisms remain active at high soil temperatures. Some of the smooth seeded varieties like Asauji are comparatively more resistant and can be sown in September. In the hills, the pea crop is sown from the middle of March to the end of May and a second crop is also sown in the autumn.

The seed-rate for the early crop should be about 100 to 120 kg per hectare and for the mid-season and late varieties the rate may be kept at 80 to 90 kg per hectare.

Seed Treatment

To reduce the root not, particularly for early sowings, seed treatment with Spergon or Arasan is helpful. In plots where a pea crop has not been grown earlier, it is advisable to treat the seeds with bacterial culture. This helps in quick nodulation and early fixation of atmospheric nitrogen.

Manures and Fertilizers

A pea crop giving a yield of 4,500 kg of green peas approximately removes 55 kg of nitrogen, 20 kg of phosphate and 40 kg of potash. A high dose of nitrogenous fertilizer may have a deleterious effect on nodule formation and nitrogen fixation. A small dose of nitrogenous fertilizer at the rate of about 25 kg of nitrogen per hectare is valuable for stimulating early growth of legumes. Phosphatic fertilizers give a good response to peas. Phosphates increase the yield and improve the quality. They favour greater nitrogen fixation by increasing the efficiency of nodule formation. Generally, 70 kg of phosphate are recommended per hectare Potassic fertilizers appear to have a good effect in increasing the yield and nitrogen fixation ability of the legumes. Best results are obtained by an application of about 50 kg of potash per hectare. The entire dose of fertilizers should be drilled at the time of sowing peas.

Farmyard manure at the rate of about 20 tonnes per hectare, if incorporated at the time of preparation of land, gives good results.

Chemical Weed Control

Most of the garden peas are sown in rows at close spacing, so it is very difficult to control weeds by mechanical aids. Chemicals have been used to control most of the annual weeds. A pre-sowing application of 2-3 litres-ha of Basalin controls most of the weeds.

Irrigation

For proper germination, a pre-sowing irrigation is advisable. If the soil moisture is less at the time of sowing, a light irrigation is advisable afterwards to ensure proper germination. Thereafter during the dry period, light irrigation may be applied at intervals of 10 to 15 days. One to two irrigations at the time of flowering and fruit-set are essential.

Vine Support

Staking is an expensive proposition. Mostly all tall varieties in the home gardens are staked. Wire trellis supported by strings is generally used. Commercial gardeners commonly do not stake their crops.

Harvesting

Garden peas must be picked at the proper stage of maturity, because they start losing their quality rapidly after reaching the edible stage. The deterioration is hastened if the temperature is high at the time of harvesting. Peas in India are generally hand-picked. Proper care should be exercised not to injure the vines by picking the pods with a jerk. About three pickings are required for harvesting most of the varieties. Uniformity is an important criterion for canning or dehydration. The quality of peas is ascertained by tenderometer reading. For fixing the dates of sowing and harvest, the help of the knowledge of heat unit or "degree days" is taken. In order to anticipate the harvest date of a given variety of peas, it is necessary to know how many heat units must be accumulated to obtain a given quality or maturity level as measured by the tenderometer.

In countries where extensive cultivation of peas is taken up for supplying peas to canning factories, harvesting is done by machines. For fresh market, the peas are graded according to the standards fixed by the country. The Indian Standards Institution has fixed three grades for peas in pods. The picking should be done either early in the morning or late in the afternoon so that the quality may not go down during the heat of noon.

Yield

Early varieties usually give about 3,000 to 4,000 kg of green pod per hectare. The midseason and late varieties give higher yields of about 6,000 to 7,000 kg per hectare.

Storage

Fresh unshelled peas may be kept for two weeks at 0° C and 90-95 per cent relative humidity. Peas can also be stored in crushed ice for about 2-3 weeks. The pods will freeze at —10° C.

Seed Production

Peas are predominantly a self-pollinated crop though in some varieties very little cross-pollination may occur. Consequently, the only isolation necessary is to have the varietal plantings spaced far enough to prevent mechanical mixtures at planting and harvest times. For stock seed production, roguing is a compulsory operation. The term rogue is applied to any off-type plant. Rogues may originate as a result of mechanical mixture, volunteer mixture, natural crossing, or by mutation. The seed stock can considerably deteriorate within a couple of years if roguing is not done. The yield of seed per hectare varies from 1500 to 2000 kg. Seed yields as high as 2500 kg are also not rate.

Diseases and their Control

A number of diseases attack peas but those which are important are wilt, blight, rust, powdery mildew and root rot

Fusarium Wilt: The fungus *Fusarium oxysporum f. pisi* causes yellowing and downward curling of leaves. The pods do not fill properly. In severe cases, no pod formation takes place. The infection gets in through the roots. If the lower part of the stem is cut open, a lemon discoloration is observed. In severe cases, the whole plant wilts and the stem shrivels. The control measure is either to follow long rotation or to use resistant varieties, e.g., **Alaska, Resistant Surprise.**

Near Wilt: This is closely related to wilt and attacks the plant at higher temperatures later in growth, sometimes when it is near maturity. The colour of the stem of the affected plant when cut open may be brick red. The varieties **Delwiche Commando** and **New Era** are resistant to both wilt and near-wilt.

Bacterial Blight: This causes water-soaked spots on the stems, leaves and stipules. A white to cream-coloured slimy ooze appears on the surface of the lesions. The infected area eventually turns brown and papery. Humid conditions favour the disease. It is seed-borne. Disease-free seeds should be used.

Rust: This often becomes serious in humid regions. The plants dry up quickly and the yield is considerably reduced.

Powdery Mildew: Appears as a dust like coating on leaves caused by *Erysiphe polygoni*. The leaves eventually turn yellow. Severe infection results in small brown spots and streaks on the stems together with dwarfing and malformation. It is also seed-borne. Dusting of sulphur controls the disease. Some resistant varieties are also available.

Root Rots: It may be due to a number of organisms which live in the soil. They become active at higher temperatures. Seed-dressing with fungicides like Spergon or Arasan, late planting and using hardy, smooth-seeded varieties for early sowing are the possible measures to combat these organisms.

The pea-mosaic virus is also becoming quite common.

Insects and their Control

The two insects which are serious for peas are the pea aphid and weevil.

Pea Aphid: The aphids attack from January onwards. The insects which are green, long-legged and soft-bodied suck the sap of younger parts of plants. The insect can be controlled by spraying malathion, rotenone or rotenone-nicotine.

Pea Weevil: It lays eggs on the young pods and the larvae bore into the seeds where they complete their development. Control of the insect may be effected by dusting the field at blossoming time with 1 per cent rotenone or 10 per cent DDT.

CHAPTER XI

Cucurbits

THIS IS the largest group of summer vegetable crops. This includes cucumber, muskmelon, watermelon, *tinda*, bottle gourd, *luffa*, bitter gourd, pumpkin, squashes, *parwal*, snake gourd and large number of mostly trailing crops. They all belong to the same family Cucurbitaceae but to a number of different genera. Most of them are monoecious in character and a few are dioecious. A number of hermaphrodite and andromonoecious cultivars are also available in some crops. They are all summer season crops and are susceptible to frost. The cultural requirements of all crops in this group are more or less similar.

CUCUMBER

(Cucumis sativus L.*)*

Hindi : *Khira*

The cucumber is an important summer vegetable in all parts of India. The cucumber is used as salad, as pickle and also as cooked vegetable. The cucumber has been cultivated in India for at least three thousand years. Cucumber seeds have a number of Ayurvedic uses. According to the Unani system of medicine, the oil from its seed is good for brain and body.

The nutritive value of cucumber per 100 g of edible portion is given below:

Moisture	96.3 g	Protein	0.4 g
Fat	0.1 g	Minerals	0.3 g
Fibre	0.4 g	Other carbohydrates	2.5 g
Calories	13	Calcium	10 mg
Magnesium	11 mg	Oxalic acid	15 mg
Phosphorus	25 mg	Iron	1.5 mg

Sodium	10.2 mg	Potassium	50 mg
Copper	0.1 mg	Sulphur	17 mg
Chlorine	15 mg	Vitamin A	Nil
Thiamine	0.03 mg	Riboflavin	0.01 mg
Nicotinic acid	0.2 mg	Vitamin C	7 mg

Taxonomy and Varieties

The cucumber belongs to the genus *Cucumis* and species *sativus*. The cucumber varieties are generally classed into four groups:

1. European-American—Some of the English cultivated varieties belong to this group.
2. West Asiatic—A very xerophytic species.
3. Chinese—Very large, long fruits with semi-glossy rind.
4. Indo-Japan—Himalayan and hermaphrodite types.

There are a large number of varieties grown throughout India. They vary from small pickling varieties to very large and thick varieties grown in Rajasthan and Gujarat. The two varieties recommended by the I.A.R.I. are **Japanese Long Green** with long green gruits, 30-35 cm in size and **Straight Eight**, a white spined, medium long, thick, straight green fruit. The other commonly grown varieties are **Poinsette, Balam Khira** and **Khira Poona.**

Climatic Requirements

The cucumber is a warm season crop and it does not withstand even light frost. It tolerates a slightly cooler weather than melons. The cucumber seed does not germinate at a temperature as low as 11°C but it may remain in cold soil for a considerable time and then germinate when the temperature becomes favourable. The seed starts giving satisfactory germination at 18°C and the speed of germination increases with the increase in temperature till 30°C. The cucumber grows best at temperatures between 18°C and 24°C.

The cucumber is subject to certain diseases which may attack parts above the ground if they are subjected to excessive rainfall or periods of high humidity. For this reason, regions having an abundance of sunshine and low humidity are ideal for the production of cucumber.

Soil Requirements

The cucumber is grown successfully on many kinds of soil from sandy to heavy clays. Where earliness is of prime consideration, a sandy or sandy-loam soil is preferred. Loam, silt loam or clay loam is preferred where heavy yields are the main consideration. The cucumber plant grows well at soil reaction between pH 5.5 and 6.7 provided the other factors are satisfactory. The soil should be well drained.

Planting

There are two general methods of sowing cucumber:

1. Hills are prepared at proper spacing by adding well-rotten organic manure and a number of seeds are sown on each hill.
2. Furrows are made at spacings which are kept from row to row and seeds are sown on the edge of the furrows either on one or both sides of the furrows. The spacing between the furrows is nearly doubled when sown on both sides. Irrigation water usually flows through these furrows. The cucumber is grown both as a summer and a rainy season crop. As a summer crop, it is sown from January to the end of February and in the rainy season in June-July. In the hills it is sown in April.

The spacing from row to row, unless staked, varies from 1½ to 2½ metres according to soil fertility and variety. The distance from plant to plant is kept at about 60 to 90 cm. Approximately 2.5 kg of seed are required for sowing one hectare.

Thinning

When the seed is sown in hills, the plants should be thinned so that not more than three plants are left standing in each hill. When sown along the furrows the plants at each place are thinned from one to two.

Manures and Fertilizers

It is difficult and even impractical to recommend a fertilizer application that has universal application. The application of 25 to 35 tonnes of well-rotten organic manure per hectare is beneficial. When organic manure is not available, excellent crops can be grown with the application of inorganic fertilizers. Even when organic matter is available, yields can generally be increased by the addition of comparatively small amounts of fertilizers. The quantity of fertilizers to be added may be estimated according to the fertility of the soil and the uptake of nutrients of cucumber. A yield of 30 tonnes per hectare removes 55 kg of nitrogen, 45 kg of phosphate and 85 kg of potash from the soil.

Sex Expression and Sex Ratio

The question of sex expression and sex ratio is of great interest in most of the cucurbitaceous crops which have monoecious plants. These bear male and female flowers separately on the same plant. Generally there are more male flowers and only female flowers bear fruits. An ideal variety is one which has high female to male flower ratio. Normally a monoecious plant bears only male flowers in the beginning. The female flower appears later. The lower the node number on which the female flower appears on the main stem, the earlier is the variety. The female to male flower ratio goes on increasing with the age of plant. Though the sex expression and sex ratio are varietal characters, they are modified by environment. Lower fertility, higher temperature, longer light period all induce maleness. Certain gases and chemicals also affect sex. Both auxins and anti-auxins at proper concentrations modify sex. Gibberellic acid at higher concentrations induces maleness but at the lower concentrations of 10 to 25 ppm increases the number of female flowers. Two sprays, one at 2-leaf stage and again at 4-leaf stage with 25 to 100 ppm of maleic hydrazide, 100 ppm of *alpha* naphthaleneacetic acid, 200 ppm of Ethrel, 3 ppm of boron or 3 ppm of molybdenum can suppress the number of male flowers and increase the number of female flowers, fruitset and ultimate yield. Silver nitrate spray induces male flowers.

Interculture Operation

The cucumber plant is shallow-rooted. Shallow cultivation should be repeated often enough while the plants are small in order to close soil cracks and control weeds. Hand-hoeing and pulling large weeds by hand may be needed after the plants begin to vine. Herbicides may be used to control the weeds.

Harvesting

Cucumbers are harvested both for fresh market and for processing. They should be picked at frequent intervals in order to avoid losses due to over-sized or over-mature fruits. Once harvesting starts, the fruits are generally picked at two to four-day intervals, depending on the weather.

Optimum temperatures for storage, handling and transit depend on the duration of storage and the use to be made of the product. If cucumbers are to be stored for no longer than two days, temperatures have little practical effect. For longer storage the temperatures should be kept at 10° C. The average yield per hectare is about 8,000 to 10,000 kg.

Seed Production

The cucumber is a cross-pollinated crop. Honey-bees are the main insect pollinators. So proper isolation distance should be kept between varieties. The acid or alkaline method of seed extraction is recommended for quick and easy extraction of the seed. Eight and a half ml of hydrochloric acid per 12 kg or twelve parts of 25 per cent technical grade ammonia per 1000 kg of freshly-threshed fruit material is thoroughly stirred into pulp. After about 30 minutes, water is added while stirring. The pulp, other impurities and empty seeds will float and mature seeds sink to the bottom. The common practice is by fermentation. The seeds are then rapidly dried to a moisture content of 6 per cent and then properly packed and stored.

Hybrid Vigour

Hybrid F_1 cucumbers give higher, earlier and total yields and also a very uniform crop. Hybrid seeds are being produced in the U.S.A., Canada, Japan and Australia. Plants with only female flowers have been isolated from the Japanese varieties. These are being used for commercial production of F_1 hybrid seed. These lines are sown in alternate rows with another monoecious line with good combining ability and left for natural cross-pollination. All fruits on the gynoecious line will produce F_1 seeds. **Pusa Sanyog** is one such I.A.R.I. recommended F_1 hybrid.

Diseases

Cucumbers are attacked by a number of diseases. In some areas diseases are the main limiting factor in profitable production of this crop. The most important diseases are bacterial wilt, anthracnose, downy and powdery mildews, angular leaf spot and mosaic.

Bacterial Wilt: This disease is caused by a bacterium *Erwinia tracheiphila* which is carried by the striped cucumber beetles. The disease spreads from leaves downwards to the petioles and stem until the entire plant wilts and dies. A cut stem shows a sticky ooze which can be drawn out into threads. There is no direct control measure but the disease can be fairly checked by controlling the striped cucumber beetle.

Anthracnose: This disease is caused by a fungus known as *Colletotrichum lagenarium*. Small yellowish or water-soaked areas, which enlarge rapidly and turn brown, appear on the leaves. The symptoms later appear on the fruits as well. Crop rotation, eradication of weeds in the field, seed treatment with a corrosive sublimate solution (2.5 ml in 35 to 40 litres of water for five minutes) followed by spraying or dusting with an insoluble copper compound are the recommended control measures.

Downy Mildew: This is caused by a fungus called *Pseudoperonospora cubensis* and is prevalent in areas with high summer rainfall and humidity. The fungus attacks only the leaves. Symptoms appear as yellow to reddish-brown spots on the upper surface of leaves, while on the lower surface the purplish spores appear in periods of high himidity. The use of fungicides to control the fungal diseases has its limitations because many of the cucurbits are readily injured by Bordeaux mixture, sulphur sprays or dusts. Dusting with tribasic copper sulphate (5 per cent copper content) at 20-25 kg per hectare early in the season, and 45-60 kg per hectare when the vines are larger is recommended to control the disease. A number of resistant varieties are **Palmetto, PR 27, Santee** and **Palomar**

Powdery Mildew: This disease is caused mainly by two fungi *Erysiphe cichoracearum* and *Sphaerotheca fuligenea*. The latter is more common in India and often becomes severe in warm, rain-free, growing areas. Symptoms first appear as round white spots on the under-surface of the older leaves. The spots enlarge, increase in number, coalesce, appear on the upper surface of the leaves, and eventually cover both surfaces. The fungus also attacks the stems. Spraying with products known as Karathane and Morestan at 30 to 50 kg per hectare can control the disease.

Systemic fungicides like Benlate, Bavistin, etc. have been found more effective to control the disease. The best control measure will be to develop varieties resistant to the disease.

Angular Leaf-spot: This disease is important only to cucumber and is caused by a bacterium *Pseudomonas lachrymans*. Symptoms appear as water-soaked lesions on leaves and fruits. The spots on the leaves are confined by the veins. They turn grey to tan in colour, and form an exudate on the lower surface. Infected fruits show a brown, firm rot, which cause rapid deterioration and extend in the flesh. Soaking the seeds for five minutes in a 1 : 1000 mercuric chloride solution, rinsing in water, and drying quickly may partially control the disease. The disease can also be controlled to some extent by spraying the plants with streptomycin formulation at 400 ppm.

Cucumber Mosaic: This disease is caused by a group of virus strains. Infected plants show a mottled mosaic leaf-pattern. The fruits on diseased plants are mottled and often distorted, malformed and whitish. The disease is rarely transmitted through seed. It is readily transmitted by aphids. The only control measure is growing resistant varieties like **Shamrok Ilima, Ohio MR-200, Ohio MR 17** and **Wisconsin, SMR-9.** The other diseases which attack cucumber are scab, fusarium wilt, verticillium wilt and root rots.

Insect Pests and Root-knot Nematodes

Cucumber is attacked by many insects. The plant can be damaged at any time during growth and all its parts are subject to attack. The insects not only damage the plant parts but also help in transmission of a number of diseases. The most important insects are red pumpkin beetles, aphids, cutworms and fruit fly.

Red Pumpkin Beetles: These are probably the most serious insect pests of cucumber. They attack the plants as soon as they come up. They eat away the interveinal space of the leaves. The control measure is to catch and destroy them early in the morning. They remain slow and sluggish before sunrise. It is difficult to catch them after sunrise. They are mostly found on the lower surface of leaves. Dusting with 1 per cent Lindane or a mixture of BHC and DDT controls the insect. DDT should be dusted with caution as it damages the young cucurbit leaves. Soil application of Furadan granules at 15 kg per hectare before sowing controls the insect.

Aphid: This small sucking insect injures the plants by sucking the juice. Aphids remain on the lower surface of the leaves. A spray with malathion controls the insect.

Cut Worms: These caterpillars hide in the soil during the day and feed at night. The soil if treated with DDT or BHC dust at the time of preparation may control the pest. If attack is detected later when the seedlings are young, a circular band around the plant with BHC or DDT dust mixed with the soil often helps.

Fruit Fly: This is a very serious pest of most of the cucurbitaceous fruits. The adults, which are a bit smaller than the housefly, puncture the skin of the ovary or the young fruit and lay eggs. The maggots after hatching start feeding inside the fruits. The infected fruits get deformed and often rot with secondary infection. The control is very difficult. The affected fruits should be plucked and destroyed along with the maggots inside them. The crop may then be sprayed with malathion in the very young stage of the fruit. The insecticide should not be sprayed at least seven to ten days before harvesting the crop. Some traps and baiting to catch and kill the adults are also recommended.

Root-knot Nematodes: These minute eelworms cause swellings or galls on the roots. The first above-ground symptoms of the pest are presence of poor growth and stunted plants. Heavily infected plants are weakened and eventually die. Soil fumigation with D.D. or application of Nemagon and long rotations can control the nematodes.

MUSKMELON

(*Cucumis melo* L.)

Hindi : *Kharbuza*

In north India muskmelon is an important dessert crop. The cultivation methods being the same as for the other vegetable crops in most parts of the world, melons are grouped under vegetables but in certain parts of the continent they are considered as a fruit. Very rarely is it cooked as a vegetable in its green stage. Muskmelons have a good inter-state trade in India. This is widely grown in Bihar, Uttar Pradesh, Punjab and Rajasthan. In the south, it is grown in Andhra Pradesh and Tamil Nadu. It is supposed to be very wholesome and nutritious. It also prevents constipation. The nutritive value varies from variety to variety. A rough analysis of the food value is given below:

(per 100 g of edible portion)

Moisture	92.8 g	Iron	1.3 mg
Protein	0.6 g	Sodium	4.6 mg
Fat	0.1 g	Potassium	341 mg
Minerals	0.6 g	Copper	0.03 mg
Fibre	0.5 g	Sulphur	32 mg
Other carbohydrates	5.4 g	Vitamin A	450 I.U.
Calories	25	Thiamine	0.11 mg
Calcium	65 mg	Riboflavin	0.08 mg
Magnesium	31 mg	Nicotinic acid	0.05 mg
Phosphorus	20 mg	Vitamin C	32 mg

Origin

There is still some controversy about the exact place of origin of muskmelons. It has a Sanskrit name. It is now generally agreed that the melon is native to the hot valleys of Iran (Persia) and North-West India.

Taxonomy and Variety

The muskmelon belongs to the family Cucurbitaceae, genus *Cucumis* and species *melo*. *Phunt* and *Kakri* also belong to this species. There are a large number of varieties of the muskmelon, with different sizes, shapes and colours, grown in different parts of the country. Hardly any improvement work has been done on this crop in India. In foreign countries, very sweet varieties have been developed with small seed cavity, thick flesh, good flavour and resistant to diseases like powdery and downy mildews and fusarium wilt. Some exotic varieties are **PMR 45, Jacumba** and **Campo.** The netted varieties are commonly known as cantaloupe in the U.S.A.

There is need to improve and group the muskmelon varieties of India. At present the general cultivated varieties are:

I.A.R.I.: **Pusa Sharbati, Pusa Madhuras**
I.I.H.R., Bangalore: **Arka Jeet** and **Arka Rajhans**
U.P.: **Lucknow-Safeda, Haridhari, Faizabadi,** etc.
Punjab: **Kutana, Amritsari, Haramadhu, Punjab Sunehari**
Rajasthan: **Durgapura Madhu** and **Tonk** varieties.

A variety **Sarda** is grown in Afghanistan and is available in India in October-November. The variety is not only sweet, thick-fleshed with a good flavour but has also an exceedingly good keeping quality. Attempts are being made to find out a region in India where this variety can be grown maintaining all its qualities.

Climatic Requirements

The muskmelon requires a high temperature and dry climatic conditions. A humid climate may favour the development of foliar diseases. Excessive moisture in the soil when the fruits mature, lowers the quality of the fruit. The optimal temperature for the growth of melon is about 30°C. It cannot stand any frost.

Soil and Soil Preparation

Muskmelons are mainly grown on sand and sandy soils on river-beds but this crop can be raised even on sandy loams, silt loams and clay loams. They do not grow well on a strongly acidic soil, the optimum pH range being between 6.0 and 6.7. The soil should be well prepared as for other cultivated cucurbits. When sown on the river-beds, the sand is dug up to the water-table and then it is filled up after mixing the manure with the soil. Digging is done either in hills or trenches.

Manures and Fertilizers

The manure and fertilizer requirements are the same as those for cucumber. A yield of 16,850 kg of fruit removes approximately 60 kg of nitrogen, 18 kg of phosphate, 110 kg of potash, 77 kg of calcium and 16 kg of magnesium per hectare. The manurial doses will vary according to the fertility of the soil. The quantity to be applied can, however, be easily arrived at after knowing the fertility of soil and the quantity of uptake of nutrients.

Time of Sowing and Seed Rate

The muskmelon is grown as a summer crop and is sown from November to March. In regions where there is no danger of frost like Bengal, Bihar and the south, it is sown in November-December. In northern India it is generally sown after the danger of frost is over, that is, from February onwards. To get an early crop, it can be sown in December-January but needs protection from frost. The seed is soaked overnight before sowing. In the hills it is sown in April-May. About 1½ kg of seed is needed to sow one hectare.

Irrigation and Weed Control

Crops sown on the river-beds do not need any irrigation. The plants get moisture through capillary action from the sub-soil water. The crop sown elsewhere needs irrigation particularly in the Rajasthan area. The crop requires an abundance of moisture during the early part of the vine growth. Once the melons are fully grown, over-watering should be avoided. Regular interculture operations are done to eradicate the weeds. Thinning of plants is done as described for cucumbers. Mulching, particularly with black polythene, suppresses the weeds and increases the yield.

Harvesting

The stage of maturity at which melons should be harvested depends on different factors like variety, temperature, distance of market and method of shipment. The stage of maturity is generally judged by the change in the external colour of the fruit. As ripening advances, a crack develops around the peduncle at the base of the fruit, and when fully ripe, the fruit slips easily from the stem, leaving a large scar. This is known as the "full-slip". In the "half-slip" stage, only a portion of the disc is removed when the fruit is pulled out and the scar on the fruit is smaller than in the "full-slip" stage.

Yield

The yield will depend on many factors. However, the average yield per hectare is 10,000 to 12,000 kg.

Storage

Ordinarily, melons are not stored. However, melons can be stored for a week or more at 0 to 1°C at 90 per cent relative humidity.

The diseases and pests are mostly the same as those for cucumber. It is interesting to note that in the U.S.A. in the search for a variety resistant to powdery mildew, a collection from India proved highly resistant. Most of the earlier mildew-resistant varieties in the U.S.A. were developed from this. Some of the mildew-resistant varieties there are **PMR Cantaloupe 45, PMR 6,7 & 8, Campo, Jacumba** etc. Varieties resistant to fusarium wilt are **Golden Gopher, Iriquois, Minnesota Midget, Harvest Queen, Delicious 51,** etc. **Purdue** 44 is resistant to Alternaria leaf spot and **Texas Resistant** is resistant to both downy mildew and aphids.

WATERMELON

(*Citrullus lanatus* (Thunb.) Matsumura & Nakai)
Hindi : *Tarbuz*

Africa is considered to be the place of origin of the watermelon. It has been in cultivation for a long time in India which is often considered as the secondary centre of its origin. It is a very common summer crop and is grown from the lower Himalayan regions to south India. The fruits are delicious and sweet when ripe, very seldom cooked as vegetable when immature. The seeds are also fried and eaten. It is comparatively poor in its nutritive value. A rough estimate of its nutritive value is given below:

(per 100 q of edible portion)

Moisture	95.8 g	Iron	7.9 mg
Protein	0.2 g	Sodium	27.3 mg
Fat	0.2 g	Potassium	160 mg
Minerals	0.3 g	Copper	0.05 mg
Fibre	0.2 g	Sulphur	42 mg
Other carbohydrates	3.3 g	Vitamin A	Nil
Calories	16	Thiamine	0.02 mg
Calcium	11 mg	Riboflavin	0.04 mg
Magnesium	13 mg	Nicotinic acid	0.1 mg
Oxalic acid	11 mg	Vitamin C	1 mg
Phosphorus	12 mg		

Taxonomy and Variety

The watermelon belongs to the family Cucurbitaceae, genus *Citrullus* and species *lanatus*.

There are a large number of varieties grown all over the country. This being a cross-pollinated crop and as hardly any care is taken to maintain its purity, a mixture of varieties are grown in most places. The varieties are mainly known after the place where they are grown. There is a great necessity for classifying the varieties into different groups. Some of the exotic and indigenous varieties which have performed well at the I.A.R.I. are:

Asahi Yamato: A Japanese collection with fruits about 6 to 7 kg, skin light green with light stripes, flesh red, sweet and small seeded.

Sugar Baby: A collection from the U.S.A. with fruits about 4 to 6 kg, skin dark bottle green with faint stripes, flesh red, sweet and small seeded.

New Hampshire Midget: Fruits small (1.5 to 2 kg), skin light green with black stripes, flesh red, good as a home garden variety.

***I.I.H.R.** recommends **Arka Jyoti** and **Arka Manik**

Among the indigenous varieties which perform well under Delhi conditions are **Delhi Local, Pusa Rasaal** and **Katagola.** The last one has a very good keeping quality. There are some Japanese varieties which have pine-apple coloured flesh. The indigenous varieties have good transport qualities. Rajasthan recommends **Durgapura Meetha** and **Durgapura Kesar**.

Climatic Requirements

The watermelon cannot withstand frost and needs a long growing season with a relatively high temperature. The seed does not germinate satisfactorily below 21°C. Temperatures below 4.5°C which may not kill the plant can cause severe damage by checking the growth of the young plants. Foliage diseases are more destructive in humid regions. The optimum temperature range for satisfactory growth is between 22°C and 25°C.

Soil Requirements

Watermelons can be grown on a wide variety of soils ranging from high sandy loams to clay loam. Generally it is cultivated on river-beds. It is either cultivated in trenches or in hills depending on the depth of the water-table. On river-beds where the watertable is deep it is sown in hills, otherwise trenches are dug. This crop is one of the few vegetables that grow well on a soil that is rather highly acidic, even up to pH 5.0. The optimum pH for the watermelon ranges from 5.5 to 7.0.

Manures and Fertilizers

As comparatively little work has been done on the manurial requirements of the watermelon, no record has yet been published on any such work in India. Generally about 300 to 350 quintals of sludge, municipal compost or farmyard manure per hectare is added in sandy soils. This is applied at the time of preparation of the plot. It is followed by application of 75 to 80 kg of nitrogen per hectare. Application of 50 kg each of phosphate and potash is beneficial. The full doses of phosphate and potash and half of nitrogen are added at the time of preparation of soil. The second dose of nitrogen is added as a top-dressing about a month after sowing. The manurial doses, of course, should vary according to the fertility of the soil.

Time of Sowing and Seed Rate

The sowing of the watermelon is done immediately after the muskmelon from November to March. When planted in hills, about half a dozen seeds are sown in each. The spacing varies with soil fertility and variety. Hills are prepared in a square system at a distance of 3 metres each way. In the furrow system, the spacing is kept at 4×1 metre and 3 to 4 seeds are sown at each place. The seed rate per hectare varies from 2 to 2.5 kg. depending on the size of the seed and spacing. Irrigation and weed control are the same as those for the muskmelon.

Thinning

Thinning of plants is done when the danger of frost and red pumpkin beetles is over. Two or three plants per hill and one or two at each place when sown in trenches are kept. Where bigger size fruits at the cost of number are required, fruit-thinning at the earlier stages is done.

Production of Seedless Watermelon

To avoid discomfort of spitting out the seeds at the time of eating, attempts are being made to produce seedless watermelons. The application of plant regulators to produce seedless watermelons has not yet been a success. A Japanese scientist, Dr. Kihara, however, demonstrated that seedless watermelons can be raised in certain varieties by producing triploids. Tetraploid watermelons were produced by treating with clochicine and then crossed with the pollen grains collected from diploids. The seeds collected are sown along with some diploid which acts as a polliniser. The seeds in the fruits borne on triploid plants contain only small ovules which can be eaten with the flesh. Commercial triploid seeds are now available in some advanced countries like Japan and the U.S.A. The best combination found at the I.A.R.I. is Tetra 2×Pusa Rasaal and has been named **Pusa Bedana**. Tetra 2 is a very attractive and stable tetraploid variety.

Sex Modification by Plant Regulators

Application of 2, 4-5 tri-iodobenzoic acid (TIBA) at 25-50 ppm once or twice at the 2-leaf and again at the 4-leaf stage induces a greater number of female flowers, increases fruit-set and ultimately gives a 50 per cent greater yield than untreated plants. Boron and molybdenum at 3 ppm and calcium at 20 ppm are also very effective.

Harvesting

It is very important that watermelons should be at the proper stage of maturity when they are harvested. Size of the fruit and colour of the rind are not good indications to know the proper stage. Change of colour of the portion of the fruit which rests on the ground is a useful guide, the colour changing from white to creamy yellow at maturity. A metallic sound when the melon is tapped with the back of the hand denotes immaturity, whereas a heavy dull sound indicates ripeness. The dying of the tendril at the stem end is also a sign of maturity. The smooth appearance and the total absence of hair on the stem which attaches the melon to the vine is also taken as a guide. However, the knack of telling a ripe melon comes with experience.

Storage

When harvested ripe and handled carefully, watermelons keep well for 1-3 weeks at 2.2°C to 4.4°C and 80-85 per cent relative humidity. They can be shipped to long distances, even without refrigeration. Colour, sugar content and flavour, the chief attributes of a ripe watermelon, do not increase appreciably after it has been picked but there is a gradually softening of the pulp around the seed.

Insect Pests and Diseases

The important insect pests and diseases are nearly the same as those described for cucumber. There are a number of varieties evolved resistant to Fusarium wilt and anthracnose. The varieties which have been reported as being resistant to Fusarium wilt are **Hawkesbury, Klondike R-7, Kleckly Resistant, Leesbury, Miles, Baby Klondike, Ironsides,** etc. The varieties reported as resistant to anthracnose are **Congo, Dunbarton, Garrisonian,** etc. Some varieties have been reported to be resistant to both Fusarium wilt and anthracnose. They are **Calhoun Sweet, Fairfax, Blackstone,** etc.

BOTTLE GOURD

(*Lagenaria siceraria* (Molina) Standl.)
Hindi : *Kaddu, Lauki, Ghia*

The bottle-like shape of the fruit and its use as a container of wines and spirits in the past gave it the common name of bottle gourd. It is extensively grown in India. The fruits in the green stage are used as vegetables and also for preparation of some sweets. The hard shell of the fruit has many uses. They are used as water jugs, domestic utensils, making musical instruments, floats for fishing nets and many other purposes. The pulp and the young stem and leaves have many medicinal values. The bitter fruits are poisonous and are used as a strong purgative. The nutritive value of the bottle gourd is given below:

(per 100 g of edible portion)

Moisture	96.1	g	Protein	0.2	g
Fat	0.1	g	Minerals	0.5	g
Fibre	0.6	g	Other carbohydrates	2.5	g
Calories	12		Calcium	20	mg
Magnesium	5	mg	Phosphorus	10	mg
Iron	0.7	mg	Sodium	1.8	mg
Potassium	87	mg	Copper	0.03	mg
Sulphur	10	mg	Vitamin A	Nil	
Thiamine	0.03	mg	Riboflavin	0.01	mg
Nicotinic acid	0.2	mg	Vitamin C	6	mg

Remains of gourd have been found in Mexican caves dating back to 7000-5500 B.C. The rinds of bottle gourd have been discovered in an Egyptian tomb dating back to about 3500-3300 B.C. After observing the growth of wild related forms, it has now been concluded that the bottle gourd might have originated in Africa and been carried to America without the assistance of man. It has been seen experimentally that mature gourds may be carried from Africa to South America by ocean currents and the seeds inside remain viable for quite a long time.

Taxonomy and Varieties

The bottle gourd belongs to the family Cucurbitaceae, genus *Lagenaria* and species *siceraria*. Thousands of years of cultivation of this cross-pollinated crop has resulted in a large variation in the shape and size of the fruits. These vary from very long and slender to thick and round. There are different varieties especially suited for summer and the rainy season. Each state and each locality have varieties named locally. It is, however, with difficulty that one can get a pure variety. There is a wealth of variability and therefore a very good scope for collection and classification of varieties exists. The I.A.R.I. recommends two summer varieties, **Summer Prolific Long** and **Summer Prolific Round** and Pusa Naveen for summer as well as rainy season I.I.H.R. recommends **Arka Bahar.**

Climatic Requirements

It is a summer crop but can withstand cold climate better than the muskmelon and the watermelon. However, it cannot withstand frost. Most of the varieties are season-bound and so different varieties are recommended for summer and for the rainy season.

Soil and Manurial Requirements

The soil requirements are the same as for the other cucurbits. Neutral soil is best but a satisfactory yield is usually obtained at pH 6.0 to 7.0. It is a shallow-rooted crop and responds well to top-dressing of fertilizers. The bottle gourd does not grow well on poorly manured soils. There is hardly any work recommending the manurial requirements of the bottle gourd. The general practice is to apply about 50 to 60 tonnes of farmyard manure or municipal compost at the time of preparation of land followed by the application of 60 kg of phosphate and 50 kg of nitrogen per hectare.

Sowing Time, Seed Rate and Spacing

The sowing time is the same as that for cucumber. About 4 to 5 kg of seed is required per hectare. The spacing kept is the same as for the watermelon. The summer crop is not staked. The rainy season crop is usually staked, often trained on a bower made of bamboos and sticks.

Hybrid Vigour

Work at the I.A.R.I. has shown that the bottle gourd expresses heterosis at all levels of fertility. The higher the fertility of the soil, the higher such expression. The best combination for the long type is Pusa Summer Prolific Long Sl. No. 2 (**Pusa Meghdut**), and for the oblong type Sl. No. 412 and for round type Pusa Summer Prolific Round Sl. No. 11 (**Pusa Manjari**). There is a good scope for the commercial use of hybrid vigour in this crop as the cost of F_1 seed production is not much, it being a monoecious crop.

Use of Plant Regulators and Chemicals

Experiments have shown that two sprays, one at 2-leaf and again at 4-leaf stage with different plant regulators and some chemicals can increase the number of female flowers, fruit-set and ultimate yield of fruits. The most effective plant regulators are maleic hydrazide (MH) and 2, 4-5 tri-iodobenzoic acid (TIBA) at 50 ppm. Boron at 3 ppm and calcium at 20 ppm are also very effective.

Harvesting

The fruits should be harvested when they are still tender. The fruit should be separated by cutting with a knife. The average yield per hectare is 15,000 to 20,000 kg.

The insect pests and diseases are the same as those of cucumber.

PUMPKIN AND SQUASHES OR VEGETABLE MARROW

Hindi : *Sitaphal* (English : Pumpkin) *Cucurbita moschata* Poir.
Hindi : *Chappan Kaddu* (English : Summer Squash) *Cucurbita pepo*. L.
Hindi : *Vilayati Kaddu* (English : Winter Squash) *Cucurbita maxima* Dusch.

There is a lot of confusion in the correct identification of the pumpkin. Commonly all three are known as pumpkin. The common *sitaphal* grown throughout India is *C. moschata*. The summer squash is cooked when green and is grown in summer only. *C. maxima* is grown mostly on the hills. Pumpkin is grown throughout India because of its good storage and transport qualities. A number of different preparations are made from this popular vegetable. The young leaves, tender stems and flowers are also cooked. The nutritive value of the pumpkin is given below:

(per 100 g of edible portion)

Moisture	92.6	g	Protein	1.4	g
Fat	0.1	g	Minerals	0.6	g
Fibre	0.7	g	Other carbohydrates	4.6	g
Calories	25		Calcium	10	mg
Magnesium	14	mg	Phosphorus	30	mg
Iron	0.7	mg	Sodium	5.6	mg
Potassium	139	mg	Copper	0.20	mg
Sulphur	16	mg	Chlorine	4	mg
Vitamin A	84	I.U.	Thiamine	0.06	mg
Riboflavin	0.04	mg	Nicotinic acid	0.5	mg
Vitamin C	2	mg			

The pumpkin has been in cultivation since pre-historic times. All three forms have originated from the tropical Americas. Evidence found in ancient Red Indian tombs shows that pumpkin and squash were used as food in 2000 B.C. They all belong to the family Cucurbitaceae.

Varieties

There are a large number of varieties of pumpkin available in India. They vary in shape, size and colour of flesh. Hardly any attempt has been made to select good varieties and maintain them in pure form. The common varieties are : **Large Red, Large Round, Yellow Flesh** and **Red Flesh.** For the south, Tamil Nadu Agricultural University recommends **CO.I** and I.I.H.R. **Arka Chandan**. Many imported varieties of summer and winter squash are available in other countries. Some of them are : **Early Yellow Prolific, Australian Green Butternut, Green Hubbard** and

Golden Hubbard. Arka Suryamukhi, a winter squash variety has been recommended by I.I.H.R., Bangalore, I.A.R.I. has recently released **Pusa Alankar,** a F_1 hybrid.

Climatic Requirements

The pumpkin is a warm season crop, but is not as sensitive to frost as melons. It grows well in regions with a comparatively low temperature and high humidity. The plant is also tolerant to partial shade and is often grown in corn fields. Pumpkin varieties require 110-120 days to reach maturity. So a frost-free season of about four months is essential for their growth.

Soil Requirements

The soil and cultural requirements are nearly the same for pumpkins as well as for squashes. They can grow well on any good soil provided it is well drained. These have a spreading but rather shallow root system. The plants can be grown on a medium acid soil but do best at a pH of 6.0 or 6.5.

Sowing Time and Seed Rate

The seed is generally sown from January to March in the plains for the summer crop. On river-beds to get an early market crop, it is sown even in December and is protected from frost by windbreaks. It is often sown in potato fields before harvesting potatoes. For the rainy season crop seeds are sown in June-July. In the hills, seeds are sown in March-April. The average number of seeds per 100 g is 600. The seed rate per hectare is 7 to 8 kg.

Other cultural operations are the same as for the bottle gourd except for the spacing of some bushy varieties. The spacing for these varieties is closer.

Harvesting and Yield

High-quality pumpkins and winter squashes should not be har-ested until they are fully ripe, that is, when the rind has hardened. A portion of stem attached is left at the time of harvest. The fruits are placed on small piles or in a heap and then allowed to dry in the sun or cured for a few days. The recommended storage temperatures are 15-20°C for the first 2-3 weeks and then 10-15°C as a holding temperature at 75 per cent relative humidity.

Summer squashes are gathered green before the seed ripens. They are gathered when they are very tender and pale green in colour and hardly grown one-third. The fruit is removed from the plant by a slight twist and with practically no portion of the stem attached. This fruit cannot be stored for long and does not stand long-distance transport. The average yield is 25,000 kg per hectare. The insect pests and diseases are the same as for the cucumber and the bottle gourd.

BITTER GOURD OR BALSAM PEAR

(Momordica charantia L.*)*

Hindi : Karela, Kareli

The bitter gourd is grown extensively throughout India. The fruits are cooked in many ways and are quite commonly used fried, boiled, stuffed and cooked and also in curries. The bitter taste is liked by some and is supposed to contain some medicinal properties. The small varieties are rich in iron and vitamins. The nutritive values of the large and small varieties are given below:

(per 100 g of edible portion)

	Large	*Small*
Moisture	92.4 g	83.2 g
Protein	1.6 g	2.1 g
Fat	0.2 g	1.0 g
Minerals	0.8 g	1.4 g
Fibre	0.8 g	1.7 g
Other carbohydrates	4.2 g	9.8 g
Calories	25	60
Calcium	20 mg	50 mg
Magnesium	17 mg	21 mg
Phosphorus	70 mg	140 mg
Iron	1.8 mg	9.4 mg
Sodium	17.8 mg	2.4 mg
Potassium	152 mg	171 mg
Copper	0.18 mg	0.19 mg
Sulphur	15 mg	21 mg
Chlorine	8 mg	8 mg
Vitamin A	210 I.U	210 I.U.
Thiamine	0.07 mg	0.07 mg

Riboflavin	0.09 mg	0.06 mg
Nicotinic acid	0.5 mg	0.4 mg
Vitamin C	88 mg	96 mg

Origin, Taxonomy and Varieties

The bitter gourd is believed to have originated in the tropics of the old world and is widely distributed in China, Malaysia, India and tropical Africa. It is found growing wild in many areas of India. It belongs to the family Cucurbitaceae and genus *Momordica*. There are 60 species out of which only two are important as vegetable, *charantia* and *dioica*. There are not many recognised varieties of the bitter gourd in India. There is a good range of variability available in shape, size and colour. The varieties can be broadly classified into small-fruited, seven to ten centimetres long and large-fruited, 15 to 18 centimetres long. The former is generally grown in the summer season and the latter in the rainy season. A released variety of I.A.R.I. is **Pusa Domousmi.** U.P. recommends **Kalianpur Baramasi** and Tamil Nadu, **Coimbatore Long,** Kerala **Priya** and I.I.H.R. **Arka Harit** and **Pusa Vishesh**

Sowing Time and Seed Rate

In the plains the summer season crop is sown from January to March, whereas the rainy season crop is sown from June to July. In the hills, the seed is sown from March to June. 100 g of seed will count about 700. The seed rate per hectare is 5 to 6 kg. In the rural areas seed extracted from ripe fruits is mixed with cowdung and dried on the walls in the form of cakes. After thoroughly drying, the seed embedded in the cakes are stored in the containers. This treatment ensures quicker and better germination.

Manures and Fertilizers

These are the same as those for the bottle gourd as till now specific information is not available. Other cultural operations are the same as those for bottle gourd or cucumbers.

Hybrid Vigour

Increased yields have been reported by the use of F_1 hybrids. The present problem is to fix and maintain the varieties before utilising hybrid vigour.

Harvesting and Yield

Harvesting is done when fruits are still young and tender. On ripening the fruit changes its colour from green to yellow and orange. Picking may be done every alternate day. If the fruits are not picked when tender and allowed to ripen on the vines, the bearing becomes reduced. The yield varies from 8,000 to 14,000 kg per hectare with an average of 10,000 kg.

Insect Pests and Diseases

The insect pests and diseases are the same as for other cucurbits The fruit fly is a major problem and proper care for its control ensures a good harvest.

SPONGE GOURD

(*Luffa cylindrica* Roem.)
Hindi : *Ghiya tori, Nenua*

The sponge gourd is a very common vegetable grown throughout India. Out of the two *Luffa* species the sponge gourd is more commonly cultivated in Europe and the Americas. The fruit is edible when young. The dry inner fibre portion of the mature fruit is used for bathing purposes, cleaning utensils, in making shoe soles and also as filters in factories. Some industrial oil is also extracted from its seed.

The exact place of origin of the sponge gourd is difficult to pinpoint. There is no Sanskrit name for this plant. There is very little variation in either vine or fruit—a trait not generally associated with plants with a long history of cultivation. These suggest that it is a comparatively recent addition to the existing list of vegetable crops. However, it is considered that the sponge gourd is indigenous to tropical Asia, probably India.

Taxonomy and Varieties

It belongs to the family Cucurbitaceae and genus *Luffa*. There are eight species under this genus. Only two, *cylindrica* (sponge gourd) and *acutangula* (ridge gourd), are important as vegetable crops. There are not many recognised varieties of the sponge gourd. The recommended variety from the I.A.R.I. is **Pusa Chikni** which has smooth green fruits.

Other requirements and cultural operations are the same as for the bottle gourd.

RIDGE GOURD

(*Luffa acutangula* Roxb.)
Hindi : *Kali tori, Jhingli*

The ridge gourd is not a known vegetable in the Western countries. It is commonly grown all over India but is more popular in the south and the east. There is very little difference in the nutritive value between these two species of *Luffa*. The analysis, as done by the Nutritional Research Laboratory, Coonoor, is given below:

(per 100 g of edible portion)

Moisture	95.2	g	Protein	0.5	g
Fat	0.1	g	Minerals	0.3	g
Fibre	0.5	g	Other carbohydrates	3.4	g
Calcium	40	mg	Calories	17	
Phosphorus	40	mg	Magnesium	11	mg
Oxalic acid	27	mg	Iron	1.6	mg
Potassium	50	mg	Sodium	2.9	mg
Sulphur	14	mg	Copper	0.16	mg
Vitamin A	56	I.U.	Chlorine	7	mg
Riboflavin	0.01	mg	Thiamine	0.07	mg
Vitamin C	5	mg	Nicotinic acid	0.2	mg

Varieties

There are more variations observed in the ridge gourd than in the sponge gourd. The varieties range from one metre to a few centimetres. Very long varieties are available in the south particularly in Andhra Pradesh. The recommended variety of the I.A.R.I. is **Pusa Nasdhar.** Common varieties of the ridge gourd are monoecious like the bottle gourd, the bitter gourd, the pumpkin, etc. They bear the male and female flowers separately on the same plant. However, a hermaphrodite variety known as **Satputia,** is available in the ridge gourd. The fruits of this variety are small and are borne in clusters.

Other requirements and cultural operations are the same as those for the sponge gourd.

Seed Production

Gourds are cross-pollinated crops, so sufficient isolation distance between two varieties is required while producing seeds. The flowers of the ridge gourd are pale yellow in colour, whereas those of the sponge gourd are deep yellow in colour. The flowers of the former open in the afternoon, while those of the latter do so in the morning. Crossing is therefore, a success only when artificially pollinated. In nature hardly any cross-pollination between the two *Luffa* species is observed.

ASH GOURD or WAX GOURD

(*Benincasa hispida* (Thunb.) Cogn.)
Hindi : *Petha*

The ash gourd is classified under cucurbits of minor importance though it is cultivated in almost every part of India. The immature fruit is cooked as a vegetable. The fruit is largely used for making confectionery. It is generally prized because of its medicinal value. It is said to be good for patients having a weak nervous system. The nutritive analysis of the ash gourd is given below:

(per 100 g of edible portion)

Moisture	96.5	g	Protein	0.4	g
Fat	0.1	g	Minerals	0.3	g
Fibre	0.8	g	Other carbohydrates	1.9	g
Calories	10		Calcium	30	mg
Phosphorus	20		Iron	0.8	mg
Vitamin A	Nil		Thiamine	0.06	mg
Riboflavin	0.1	mg	Nicotinic acid	0.4	mg
Vitamin C	1				

Origin, Taxonomy and Varieties

The ash gourd is supposed to have originated from Japan and Java. The cultivation of wax gourd in China is very ancient. It is difficult to say when the cultivation of this crop started in India.

It belongs to the family Cucurbitaceae, genus *Benincasa* and species *hispida*. There are hardly any recognised varieties as no work for the improvement of the ash gourd has been taken up. Normally, round and oblong types are available with the size of the fruits varying from two to ten kg. Tamil Nadu recommends co. 1 and co. 2.

Other requirements are the same as those for the pumpkin.

SQUASH MELON or ROUND GOURD

(Cirullus vulgaris var. *fistulosus)*

Hindi : *Tinda*

The squash melon is one of the most popular summer vegetables in north India, especially in the Punjab, western Uttar Pradesh and Rajasthan. The fruits are harvested and cooked alone or mixed with other vegetables or pulses when the seed is still soft. The round melon has higher nutritive qualities than most of the other cucurbits. It contains:

(per 100 g of edible portion)

Moisture	93.5	g	Protein	1.4	g
Fat	0.2	g	Minerals	0.5	g
Fibre	1.0	g	Other carbohydrates	3.4	g
Calories	21		Calcium	25	mg
Magnesium	14	mg	Oxalic acid	2	mg
Phosphorus	24	mg	Iron	0.9	mg
Sodium	35	mg	Potassium	24	mg
Copper	0.12	mg	Chlorine	44	mg
Vitamin A	23	I.U.	Thiamine	0.04	mg
Riboflavin	0.08	mg	Nicotinic acid	0.3	mg
Vitamin C	18	mg			

Origin, Taxonomy and Varieties

The squash melon is believed to have originated in India. Though it is grouped under the same genus as the watermelon, its chromosome number is different. Some taxonomists think that it is nearer to the muskmelon. The Indian Institute of Horticulture Research, Bangalore has recently released a variety known as **Arka Tinda**. Two types are commonly grown — one with a light green colour and the other with a dark green colour.

Methods of cultivation and requirements are the same as those for other cucurbits. The crop becomes ready after 45-50 days of sowing. The first flush of fruit is borne very early. These fruits remain very small and should be removed as soon as they appear for proper vegetative growth. The fruits of the later flush attain marketable size and are harvested when still tender and somewhat hairy and the seeds inside the fruits are still soft. The average yield per hectare is 10,000 kg.

SNAKE GOURD

(Trichosanthes anguina L.*)*
Hindi : *Chichinda*

The snake gourd occupies a pride of place among vegetables particularly in south India, where it is most commonly grown. It is also grown in north India but mostly on the home garden scale. Gradually its commercial cultivation is spreading in the northern state as a rainy season crop. The fruits are harvested and cooked green and have the following nutritive value:

(per 100 g of edible portion)

Moisture	94.6	g	Protein	0.5	g
Fat	0.3	g	Minerals	0.5	g
Fibre	0.8	g	Other carbohydrates	3.3	g
Calories	18		Calcium	50	mg
Magnesium	53	mg	Oxalic acid	34	mg
Phosphorus	20	mg	Iron	1.1	mg
Sodium	25.4	mg	Potassium	34	mg
Copper	0.11	mg	Sulphur	35	mg
Chlorine	21	mg	Vitamin A	160	I.U.
Thiamine	0.04	mg	Riboflavin	0.06	mg
Nicotinic acid	0.3	mg	Vitamin C		Nil

Origin, Taxonomy and Varieties

The snake gourd is found growing wild in India and the Indian Archipelago is thought to be its place of origin. It belongs to the family Cucurbitaceae and to the genus *Trichosanthes*. There are two cultivated species under this genus, *anguina* and *dioica*. The former (snake gourd) is monoecious and the latter is dioecious in nature. The flowers are white and fringed.

There are no recognised varieties in snake gourd. Some selections of Coimbatore and Poona are quite good. Generally two types, one light green with white stripes and the other dark green with yellowish or pale green stripes, are cultivated. The fruit is 50 to 100 cm long. The soil and climatic requirements and the method of cultivation are the same as for other cucurbits. The crop is generally grown during the rainy season and staked. The crop is trained on pandals or trellis. Sometimes to have the fruits long and straight a small weight is tied at the lower end of the developing fruit. The seeds of the snake gourd and the bitter gourd take 7 to 10 days to germinate. It was seen that if freshly-extracted seeds are dried and stored in cowdung, they germinate quickly and better.

Yield

The crop is quick-growing and in about 7 to 8 weeks tender fruits are ready for harvest. The period of harvest lasts for about 6 weeks. The average yield per hectare is 100 quintals.

POINTED GOURD

(Trichosanthes dioica Roxb.*)*

Hindi : *Parwal*

The parwal is one of the most nutritive and wholesome vegetables. It is easily digestible, diuretic and laxative, invigorates the heart and brain and is useful in disorders of the circulatory system. This crop is widely grown in Assam, West Bengal, Bihar and Uttar Pradesh. It is an important summer crop in north Bihar and western U.P. from where it is exported to distant markets.

The nutritive analysis of the pointed gourd is given below:

(per 100 g of edible portion)

Moisture	92.0 g	Protein	2.0 g
Fat	0.3 g	Minerals	0.5 g
Fibre	3.0 g	Other carbohydrates	2.2 g
Calories	20	Calcium	30 mg
Magnesium	9 mg	Oxalic acid	7 mg
Phosphorus	40 mg	Iron	1.7 mg
Sodium	2.6 mg	Potassium	83 mg

Copper	1.11 mg	Sulphur	17 mg
Chlorine	4 mg	Vitamin A	255 I.U.
Thiamine	0.05 mg	Riboflavin	0.06 mg
Nicotinic acid	0.5 mg	Vitamin C	29 mg

Origin and Varieties

Wild forms of pointed gourd are found throughout north India. The Bengal-Assam area is the primary centre of origin. It is a dioecious crop and male and female flowers are borne on separate plants. No recognised improved varieties are available. The crop is clonally propagated and so good varieties with attractive fruit characters are available in the *parwal*-growing areas. The fruits range from small round to long, tapering at both ends. The colour varies from light to deep green with or without stripes.

Climatic Requirements

The pointed gourd requires a humid hot climate. In the north-eastern states it is taken as a summer crop. In western U.P., Delhi and Punjab, it can be grown as a rainy season crop. If left perenially at the same place, the upper part of the plant dies during winter. The roots remain dormant and with the coming of spring new sprouts come up.

Soil Requirements

A well-drained sandy to sandy loam soil is best suited to it. In north Bihar, the areas usually flooded by rivers during the rainy season are utilised for growing *parwal* during summer.

Methods of Propagation

The pointed gourd is one of the rare cucurbits which is propagated by cuttings. There are two methods usually followed. The mature vines in August-September are layered in the field and plants are separated for fresh plantings when they root. In this method the land remains occupied even after harvesting the crop. This method is also not suitable for areas which are likely to be flooded or inundated with water during the rainy season. The second method which is mostly followed is to take cuttings from mature vines and put them in the nursery. They take root and the rooted cuttings are transplanted in February-March. The crop can also be propagated by seed but this is done only while breeding for new varieties. When seeds are sown, fifty per cent of the plants are male, and most of them are to be uprooted after they start flowering.

After-care

While planting the cuttings, mostly those from female plants are chosen. To ensure proper fruit-set, about two per cent cuttings from male plants are planted at random in between the female plants. The crop is allowed to spread over the ground. Sometimes it is staked or allowed to climb on hedges or trees. The vines which are allowed to spread over the ground are more vigorous, bear more fruits and are less damaged by the fruit fly.

Harvesting and Yield

The fully-grown green fruits are picked from the vines. The average yield is 12,000 to 15,000 kg per hectare.

Diseases and pests are the same as those in other cucurbits.

CHAPTER XII

The Sweet Potato

(Ipomoea batatas Poir.*)*
Hindi : *Sakarkand*

THE SWEET POTATO is a very important crop in tropical and subtropical regions of the world. It is grown in Africa, India, China, Japan, South-East Asian countries, Latin America and southern U.S.A. In some countries this crop is often known as 'potato' and the potato is called 'white potato' or 'Irish potato'. In India it is grown on an area of about 1,91,500 hectares with an annual production of about 1,312,000 tonnes. The chief use of sweet potato is for human consumption and for manufacture of starch and alcohol. It contains 16 per cent starch, 4 per cent sugar, that is, 20 per cent alcohol-producing materials. The nutritive analysis of sweet potato is given below:

(per 100 g of edible portion)

Moisture	68.5 g	Minerals	1.0 g
Protein	1.2 g	Other carbohydrates	28.2 g
Fat	0.3 g	Calcium	20 mg
Fibre	0.8 g	Iron	0.8 mg
Calories	120	Potassium	393 mg
Phosphorus	50 mg	Thiamine	0.08 mg
Sodium	9.0 mg	Nicotinic acid	0.7 mg
Vitamin A	10 I.U.	Vitamin C	24 mg
Riboflavin	0.04 mg		

Some of the recently developed varieties in the U.S.A. have quite a high carotene content. The leaves of sweet potato are also highly nutritious and are used as a leafy vegetable in some parts.

History and Taxonomy

The sweet potato has originated in tropical America. In parts of South America, it is also called Camote or Kumara. The sweet potato belongs to the family Convolvulaceae or morning-glory family, genus *Ipomoea* and species *batatas*.

Varieties

There are hundreds of varieties of the sweet potato. In the U.S.A. the varieties are 'soft' and 'firm' according to their flesh characters. The varieties are also grouped according to their growth habits. The most common way of grouping the varieties is according to their colour, which varies from white, golden and orange to red. The recommended varieties of the I.A.R.I. are:

Pusa Suffaid: This is a selection of a white variety originally introduced from Taiwan (F.A. 17). It is high-yielding and produces medium-sized tubers of excellent quality.

Pusa Lal: This is a selection from a Japanese variety (Norin). The tubers are medium-sized, thick in the middle. The skin colour is red but the cooked flesh is white. It stores well.

Pusa Sundheri: It is a selection from material obtained from the U.S.A. The flesh colour is light orange, indicating higher carotene than other white-fleshed varieties.

A number of important selections from the different states of India have been made. Some of them are:

Bihar—**SP-3, SP-9, SP-Lalka**
Karnataka—**V12, Hosur Red** and **Hosur Green**
Tamil Nadu—**V12, V6, V8, V12, Bhadrakali, Velmon**
Punjab—**V2, V6, V8**
West Bengal—**Ranger, B 4306**

In the U.S.A. some high-yielding varieties like **Gold Rush** and **Centennial** have been evolved which produce high-quality attractive tubers.

Climatic Requirements

The sweet potato requires a long, warm growing season. It can be grown where four months in a year have warm days and nights, plenty of sunshine and moderate rainfall. It is one of the most drought-resistant vegetables. The crop is grown in tropics and sub-tropics. It does not stand frost and has to be grown during frost-free periods.

Soil and Manurial Requirements

Light soils are invariably regarded as suitable for sweet potato.

A moderate proportion of sand in the top soil with a fairly retentive sub-soil provides ideal conditions. It should be warm, loose and well drained. The roots tend to be long and slender on deep soil, so deep ploughing is not advocated. Fifteen to twenty cm depth of preparation is sufficient.

The temperature of the soil is an important factor in determining the yield of the crop. The optimum soil temperature is 20-30° C; above this the vines grow at the expense of tuber formation. The soil temperature at night is more critical than that during the day.

The sweet potato does best on a soil that is slightly to moderately acid. The optimum pH range is 5.8 to 6.7. Soils more acidic than pH 5.2 should be limed to raise the pH slightly. A high and economic yield is possible if the soil is supplied with adequate quantities of manures and fertilizers. It is estimated that 66 quintals of tubers of sweet potato remove 30 kg of nitrogen, 9 kg of phosphate and 60 kg of potash from the soil.

The presence of an adequate amount of organic matter ensures a high yield. However, excessive amount of manure should be avoided, as this may give greater vine growth at the expense of the tubers. It is advisable to add about 25 tonnes of farmyard manure per hectare in light soil and this should be supplemented by inorganic fertilizers. The response to nitrogen, phosphate and potash will depend on the fertility of the soils. In an experiment in Tamil Nadu, it has been reported that 5,500 kg of tubers removed 15 kg of nitrogen and one tonne of vine removed 20 kg of nitrogen. This shows that the soil is sure to get depleted and the productivity may go down if nitrogenous manures and fertilizers are not used. A mixture of about 60 kg of nitrogen, 60 kg of phosphate and 120 kg of potash per hectare may give a good response. Of course, the rate will depend on the fertility of the soil.

The field is laid out either into small, flat beds or ridges and furrows. Both flat beds and ridges are used in various parts of the country. The difference in yields in both these methods of planting is not significant. However, ridge planting is advocated when the crop is planted during the rainy season, or where economy of irrigation water is needed.

Propagation and Nursery Practices

Sweet potatoes are grown from 'sprouts' or 'draws' produced from tubers and from cuttings. In regions of short growing seasons, the crop is grown only from plants produced from seed tubers planted in a nursery bed. Vine cuttings are generally used as propagation material in India. In the cooler northern parts where only one crop is grown, there is usually some spring growth in the fields planted with sweet potato in the previous season. The field may be sown in early summer and will have good vine growth with frequent irrigations. In areas where the climate is not extreme, two crops are grown. In such places vines from one crop are used for planting the next crop. To get a good yield, it is advisable to plant selected tubers in the nursery and propagate by 'sprouts' as practised in regions with a short growing season.

In well-prepared nursery-beds the selected tubers are planted at a spacing of 30 cm in rows 45 cm apart. The tubers are planted 5 to 6 cm deep. The sprouts are cut and planted for further growth in another nursery. Ultimately when the nursery vines reach a sufficient length, cuttings are made and planted at about 60 cm from row to row and 30 cm within the row. About 40 to 50 thousand cuttings are required to plant one hectare. The length of the cutting will depend on the length of the internode. Each cutting should have at least four nodes. Cuttings from the upper portion of the vines should be preferred. Cuttings from the top portions produce more tuberous roots. The general practice is to bury the two middle nodes and expose the two extreme ones.

The soil around the cuttings is well compacted. The planting should immediately be followed by irrigation. During the monsoon, the cuttings should be planted when it is drizzling.

Planting time varies considerably in different parts of the country. In northern India, the vine cuttings are planted during June-July. Wherever irrigation facilities are available, earlier planting is also done. Earlier planting gives higher yields.

In central India, comprising Madhya Pradesh, Andhra, Maharashtra and Gujarat, planting is done during October-November. In some parts both *kharif* and *rabi* crops are grown. Cuttings for *kharif* are planted in May-June and for *rabi* in October-November. On the Nilgiris, the planting is done during April and May.

Inter-culture and Weed Control

In the early stages the field should be inter-cultured often to keep down the weeds. This should continue till the vines spread and cover the field. The sweet potato establishes within ten days of planting and starts growing vigorously after three weeks when it is given the first weeding. In the U.S.A. chemical herbicides like di-nitro compounds, 2,4-D, Alanap, etc., are used. The crop planted on ridges is earthed up when the crop is about two and a half months old.

Irrigation

The newly planted crop is irrigated on the fourth day after planting and again on the eighth or ninth day if there is no rain. In winter and summer 12-14 irrigations are given at intervals of ten days. The water requirement of the crop is about 30 acre-inches. Nearly 40 per cent of the sweet potato crop in Tamil Nadu is raised under rainfed conditions during the monsoon months.

Harvesting, Grading Yield and Storage

When the tubers are fully developed and mature, the leaves turn pale and later turn slightly yellow. The surface of a mature tuber if cut and exposed to the air dries up soon, while the immature ones remain moist and turn dark in colour. The harvest is best done at the correct stage of maturity. Tubers if harvested early may cause reduction in yield. The harvest even when delayed up to 5 or 6 weeks after maturity may not cause any reduction but with delays of 8 or 9 weeks there may be serious losses in yield. The crop is harvested by spades and in northern India should be dug out before the vines are completely killed by frost. The tubers after harvesting are cleaned, graded and either sent to the market or stored. The tubers should be cured before storing. The process helps in the formation of a protective layer called callus on the injured portions, particularly where the roots have been severed. The tubers are cured best at 80°C, and if 30 per cent relative humidity is maintained for ten days. Where these controlled conditions are not available the tubers are cured either at room temperature or dried in the sun for about a week.

Yield

The yield varies with the variety and the region. The yields in the irrigated area are higher than in the rainfed areas. The average yield is about 10,000 kg per hectare. Yield as high as 30,000 kg per hectare can also be obtained.

Storage

There are varietal differences in the storage qualities. Red skinned tubers generally store better than white-skinned ones. The best storage is possible in store houses provided with controlled temperature and humidity. The optimum temperature and humidity for storage are 15°C and 85 to 90 per cent. In Tamil Nadu storing the tubers successfully in a pit completely covered with straw for about two to three months has been demonstrated. However, insect damage has been reported in such storage. The main difficulties during storage are the damage by insects and fungal diseases, hardening and drying up and sprouting of tubers.

Diseases and their Control

Fortunately, no serious disease of sweet potato occurs in India. The most important diseases are stem rot or wilt and black rot.

The stem rot is caused by a fungus, *Fusarium oxysporum* f. *batatas*. The leaves of infected plants become dull in colour, then yellow between the veins and somewhat puckered. Diseased stems become blackened inside. The disease is spread through soil or diseased tubers or vines. The best method of control is to grow resistant varieties in infected areas.

The other diseases reported from other sweet potato growing countries are soft rot, pox rot, internal cork, scurf and surface rot. The last one is mainly a storage disease.

Insect Pests and their Control

The most important insect pests of sweet potato are the sweet potato weevil and the leaf-eating caterpillar. The latter is the most serious pest and is the most destructive. The adult lays eggs in small cavities in the stem. The eggs hatch in about a week; and the larval feed in the vine or in the tuber for 2 or 3 weeks. They pupate there and the adult emerges in a week's time. The adult may live for several months. The weevil continues to breed in stored sweet potato.

The control measures are to plant only tubers and cuttings known to be free from weevil, following long crop rotations; treating infested roots with an insecticide; and spraying or dusting in the place of storage with an insecticide. All the infested plant materials should be collected and burnt. The storage place after removal of the tubers should be dusted with 10 per cent DDT at the rate of 450 g for each 175 square metres of surface or sprayed with DDT using 4 kg of 50 per cent wettable powder in 500 litres of water at the rate of 7.5 litres for 100 square metres of surface. Dipping the cuttings before planting in a DDT solution or in a mixture of 500 g of lead arsenate in 50 litres of water and spraying the crop with lead arsenate at ten days' intervals at the rate of 1 to 1.5 kg in 500 litres are often recommended.

The caterpillars usually attack during the rainy season and eat the leaves. Hand-picking and destroying in the early stages of attack and dusting with 5 per cent BHC can control the insect.

CHAPTER XIII

Okra or Lady's Finger

(*Abelmoschus esculentus* (L.) Moench.)
Hindi : *Bhindi*

THE OKRA is cultivated throughout India for its immature fruits which are generally cooked as vegetable. Okra soups and stews are also popular dishes. When ripe, the black or brown white-eyed seeds are sometimes roasted and used as a substitute for coffee. The crop is used in paper industry and the stem of the plant is used for the extraction of the fibre. The fruits also have some medicinal value. The following is the nutritive value of okra:

(per 100 g of edible portion)

Moisture	89.6 g	Iron	1.5 mg
Protein	1.9 g	Sodium	6.9 mg
Fat	0.2 g	Potassium	103. mg
Mineral	0.7 g	Copper	0.19 mg
Fibre	1.2 g	Sulphur	30 mg
Other carbohydrates	6.4 g	Vitamin A	88 I.U.
Calories	35	Thiamine	0.07 mg
Calcium	66 g	Riboflavin	0.1 mg
Magnesium	43 g	Nicotinic acid	0.6 mg
Oxalic acid	8 g	Vitamic C	13 mg
Phosphorus	56 mg		

History, Taxonomy and Variety

The original home of okra is Africa. It belongs to the family Malvaceae and genus *Abelmoschus*. This genus is distinct from *Hibiscus* in having a deciduous type of calyx, whereas they are persistent in the genus *Hibiscus*. The okra belongs to species *esculentus*. There are a large number of varieties of okra and they may be classified as tall, medium-tall and dwarf according to the height of the plant. The varieties are further classified according to pod quality, some varieties are with prominent ridges, some may have slight spines, some are deep green in colour, some light green. The varieties recommended by the I.A.R.I. are **Pusa Makhmali, Pusa Sawani** and **Perkins Long Green.** Makhmali has good fruit quality but is quite susceptible to the yellow-vein mosaic virus, Pusa Sawani is deep green in colour and is tolerant to the yellow-vein mosaic virus disease. Perkin's Long Green is recommended for hilly areas. Bihar and Punjab recommend **Vaishali Badhu** and **Punjab Padmini** respectively. Maharashtra has released **Parbani Kranti** with high field resistance to ym virus.

Climatic and Soil Requirements

The okra is a warm season vegetable crop and requires a long warm growing season. The seed of okra will not germinate below 20° C. The okra is susceptible to frost and will not thrive even when there is a continuous cold spell.

The okra thrives on all kinds of soils, but it grows best in a friable well-manured soil. It is slightly tolerant to acidity. The optimum pH range is between 6 and 6.8.

Sowing Time and Seed Rate

In the plains of northern India, two sowings, one in early spring for the summer crop and the other in late summer for the rainy season crop, are done. For the summer crop in places where there is no danger of frost, as in Assam, Bengal, Orissa and Bihar, it is sown in late January or early February. In other places in western U.P., Delhi, Punjab and Rajasthan, it is sown from February to March. The rainy season crop is sown in June-July. In south India and parts of Maharashtra and Gujarat, a winter crop of okra is also raised. In the hills, seeds are sown in April-May.

For the summer crop, the seed should be soaked for twenty-four hours in water before sowing. The growth being restricted during this season, the seed is sown at a closer spacing. The seed rate for the summer crop is kept at 18 to 20 kg per hectare, whereas for the rainy season crop, it is reduced to 10 to 12 kg per hectare.

Manures and Fertilisers

About 30 tonnes of farmyard manure per hectare should be applied about two weeks before sowing *bhindi* and incorporated in the soil. Three hundred and fifty kg of superphosphate, 125 kg of muriate of potash and 300 kg of ammonium sulphate should be drilled in the rows before sowing. Three hundred kg of ammonium sulphate should be top-dressed after about a month.

Irrigation and After-care

In case the moisture is not sufficient in the soil, a pre-sowing irrigation should be given. The crop should be irrigated every fifth or sixth day during summer and whenever required in the rainy season. The crop should be weeded regularly and earthing-up in the rows should be done especially during the rainy season.

Hybrid Vigour

Hybrid vigour has been reported in certain combinations of okra. A varietal combination of Pusa Makhmali and Long White Darbhanga gave an increased yield of 60 per cent over Pusa Makhmali, a standard variety.

Harvesting

The okra fruits are continuously harvested every second or third day from the time the first pods are formed, the best time of picking being 6-7 days after the opening of flowers. Of course, this depends on the variety and the season. The growth and bearing of the plant are adversely affected if the fruits are not harvested when young.

Yield

The yield varies from 50 quintals in summer to 100 quintals in the rainy season, the average being 70 quintals per hectare. The seed is generally raised from the rainy season crop. The average seed yield is 12 quintals per hectare.

Insect Pests

The most important insect pests of the okra are jassids, shoot and fruit-borer and cotton boll worms.

Jassids: These hoppers are a serious pest of this crop. They suck the sap from the leaves, causing curling of leaves and burning effects on the edges. Spraying with a mixture of 1% of BHC and 0.1% DDT controls the insects. This is to be repeated twice or thrice for complete control. Caution must be exercised in spraying any insecticide when the fruits have started developing.

Shoot and pod borer (*Erias* spp.). The affected shoots and young fruits should be clipped along with the insect which remains inside and buried. The insecticidal spray as recommended for jassids should then be sprayed. The affected shoots can be seen from a distance as they show drying symptoms at the tips. On the buds and fruits the infection can be detected by seeing the excreta.
Cotton Boll Worms: These attack the crop at a later stage and become a problem to the seed crop. For the seed crop the insecticidal spray as recommended for jassids can control the attack.

Diseases

Two most important diseases of the okra are yellow-vein mosaic virus and powdery mildew.
Yellow Vein Mosaic: It is a vein-clearing virus disease. In severe cases, the leaves as well as the fruits become yellow and the fruiting is badly affected. The disease is transmitted only by an insect vector known as white fly. There is no resistant commercial variety. Pusa Sawani is a variety tolerant to the disease. The disease infestation is greater in the rainy season than in summer.
Powdery Mildew: Blotches of white powdery coating are found mainly on the lower surface of the leaves. The severely affected leaves turn yellow and drop off. Dust fine sulphur as soon as the disease is noticed.

CHAPTER XIV

Salad Crops

SOME VEGETABLES are consumed in the uncooked state and are known as salad crops. The knowledge of vitamin and mineral content in a number of green vegetables has made the use of salad crops very popular. The vegetables which are considered as salad crops are lettuce, celery, parsley, endive, chicory, chervil, cress and water cress. All these are cool season crops and mostly quick growing. Only lettuce and celery are grown on a commercial scale. The salad dish may include chopped-up carrots, radish, beet, onion, or any other vegetable but the above crops form the main base of the dish.

LETTUCE

(Lactuca sativa L.)

Hindi : *Salad*

Lettuce is the most popular of the salad crops. It is most commonly used in the U.S.A., but in India it is yet to gain popularity the lettuce is rich in mineral matter and vitamins. The analysis is as under:

(per 100 g of edible portion)

Moisture	93.4 g	Chlorine	23.0 mg
Protein	2.1 g	Calcium	50 mg
Fat	0.3 g	Phosphorus	28 mg
Fibre	0.5 g	Sodium	58.0 mg
Minerals	1.2 g	Sulphur	27.0 mg
Other carbohydrates	2.5 g	Vitamin A	1650 I.U.
Calories	22	Thiamine	0.09 mg
Magnesium	30 mg	Riboflavin	0.13 mg
Iron	2.4 mg	Nicotinic acid	0.5 mg
Potassium	33.0 mg	Vitamin C	10 mg

History and Taxonomy

Lettuce has been cultivated for more than 2,500 years. Cultivated lettuce originated around Asia Minor, Iran and Turkistan. Lettuce is an annual and belongs to the family Compositae or sunflower family and to the genus *Lactuca* and species *sativa*. There are four types or groups of lettuce. They are head type, variety *capitata*; leaf or cutting type, variety, *crispa*; cos, or Romain type, variety *longifolia*; asparagus type, variety *asparagina*. There are two types of head lettuce known as crisphead and butterhead.

Varieties

The crisphead varieties have firm heads of a crisp texture, plants are wholly green like **Great Lakes** or tinged brownish like **Iceberg.**

The butterhead varieties have soft solid heads; inner leaves have oily, soft, buttery or greasy texture, e.g., **White Boston**. The cos or Romain varieties have narrow leaves, elongated upright heads, *e.g.*, **Dark Green.** The varieties belonging to leaf or cutting type are **Chinese Yellow** and **Slobolt.** They are loose and do not form heads. Several leaf cuttings can be obtained. The stem types also do not form heads but are grown for their large, fleshy stems, which are peeled and eaten, *e.g.*, **Celtuce.** The recommended I.A.R.I. varieties are Great Lakes, Chinese Yellow and Slobolt.

Climatic Requirements

Lettuce does well in a relatively cool growing season with a monthly average temperature of 12° C to 15° C. High temperatures promote seed stems, cause a bitter taste in the leaves, and accelerate the development of tipburn and rot. Head lettuce rots in hot, rainy or humid weather. Lettuce seed does not germinate properly when the soil temperature is above 30°C.

Soil and Manurial Requirements

Lettuce performs best when grown on a rich, friable soil. Soils rich in organic matter have a high waterholding capacity and ensure uniform moisture supply. Lettuce is sensitive to high acidity. The best soil reaction is pH 5.8 to 6.6. The yield is low at pH 5.0 or above 7.0. The lettuce plants have mostly surface roots. The surface soil, therefore, should be well supplied with nutrients.

The fertilizer requirements will vary with the soil. However, on an average, 100 kg of nitrogen and 60 kg each of phosphate and potash per hectare when applied give good results.

Sowing

The plants are generally started in the nursery bed but sometimes some types, especially the leaf types are sown directly in the field. These are sown early in August-September and sown in rows 15 to 20 cm apart. The leaves are consumed when young and tender. The nursery sowing is done in September-October and transplanted when the seedlings are 5 to 6 weeks old. About half a kilogram of seed is required for raising seedlings for one hectare. In the hills, the seeds are sown from February to June.

After-care

Hoeing and weeding are intermittently done for proper aeration and keeping down the weeds. Water should be supplied to keep uniform moisture conditions in the soil. Drainage is as important as supplying irrigation, for excess of soil moisture may cause rotting.

Harvesting

Leaf Lettuce: These varieties are usually allowed to develop to full size though they are often cut soon after they are half-grown. *Head Lettuce*: These are harvested when the heads are well-formed, of good size, and solid. While handling care should be taken not to damage the wrapper leaves. Lettuce can be kept for 2-3 weeks at 0°C and 90-95 per cent relative humidity.

Seed-raising

Lettuce is mainly a self-pollinated crop. There is no difficulty in the production of seeds of the leafy varieties. In the head types a slight cut or tearing the upper leaves by hand helps the seed stalk to emerge easily. The leafy types produce about 500-600 kg of seed per hectare, whereas the variety, Great Lakes produces only about 100 to 125 kg per hectare.

Insect Pests and their Control

Aphids are the most troublesome insect pests on lettuce. The use of 3 or 4 per cent nicotine dust gives satisfactory control if applied when the temperature is around 18°C to 21°C.

Diseases and their Control

Slimy Soft Rot: It is the most important disease particularly in head lettuce. The disease sometimes results in considerable damage. It can be controlled by early removal of the heads and also by keeping the soil uniform in moisture and keeping the surface soil relatively dry.

Downy Mildew: The first symptoms are the appearance of light green or yellowish spots on the upper surface of leaves. A downy white growth appears on the underside of the leaves. Control of the disease is by use of certain resistant varieties like **Imperial 17.**

Mosaic: It is a virus disease first noticed in the seedling stage. There is a slight inward rolling of the leaves along the main axis followed by a light green to yellow mottling of leaves. There may be severe stunting and a dull green to slightly yellow discoloration of the whole plant. The disease is seed-borne and use of disease-free seed is the only control measure known so far.

CELERY

(Apium graveolens L.)

Celery ranks second in importance amongst salad crops. In India this crop is not commercially important as a vegetable crop. However, quite a large area in the Punjab and U.P. is diverted to the production of the seed. This is an annual crop and the seed is being exported to European countries as a condiment. Celery as a salad crop is mostly grown in kitchen or home gardens. Its leaf stalks or petioles are eaten as salads, in soups, in sauces, in puree, fried and spiced. The nutritive analysis of celery stalks is given below:

(per 100 g of edible portion)

Moisture	93.5 g	Minerals	0.9 g
Protein	0.8 g	Other carbohydrates	3.5 g
Fat	0.1 g	Calcium	30 mg
Fibre	1.2 g	Iron	4.8 mg
Calories	18	Thiamine	0.12 mg
Phosphorus	38 mg		

Vitamin A	867 I.U.	Nicotinic acid	0.3 mg
Riboflavin	0.05 mg	Vitamin C	6 mg

History, Taxonomy and Variety

The places of origin of celery extend from Sweden southward to Algeria, Egypt, Abyssinia, and in Asia even to the Caucasus, Baluchistan, and the mountains of India. Celery belongs to the family Umbelliferae, genus *Apium* and species *graveolens.* The varieties recommended by I.A.R.I. are **Standard Bearer** and **Wright Globe Giant.**

Climatic and Soil Requirements

Celerly grows best when the weather remains relatively cool with a well distributed moderate rainfall during the growing season. It does not thrive well on a soil more acidic than pH 5.5. It does not perform well at a pH above 6.7. The nutrient requirements of celery are quite high. A yield of 20 tonnes per hectare removes 140 kg of nitrogen, 55 kg of phosphate and 220 kg of potash. Celery is a shallow rooted crop. So the majority of the nutrients are drawn from the upper surface. Good quality depends on continuous steady growth.

Sowing and Transplanting

The seed is small, about 75,000 to 28.35 g. They germinate slowly. About 250 g of seed is needed for planting one hectare. The young seedling needs special attention. The seed is sown in the nursery by the end of August. The seedlings are transplanted in well manured plots after about two months. In the home gardens, seedlings are transplanted in well manured trenches. This facilitates earthing up and blanching. However, for commercial growing the seedlings are transplanted in rows 60 cm apart and 15 cm within rows.

Blanching

Excluding light from the stalks while the plants are still growing makes them devoid of chlorophyll and this is known as blanching.

Blanching is done either by wrapping paper around the leaf stalks or by earthing up soil as the plants grow. Blanching is now being discouraged as the nutritive value is reduced by this process. There are self-blanched and green varieties.

Harvesting

Each plant is cut just below the surface with a sharp knife. The plants are then trimmed and prepared for the market. Some sensitive workers may develop skin trouble while handling celery.

Celery in storage absorbs foreign flavours. So it should be kept away from the odours of other products. They are stored after harvest in trenches, cellars and cold storage. In cold storage they are kept at 0°C at 95-98 per cent relative humidity. The diseases which affect celery are early and late blights, fusarium yellow and pink rot. The virus diseases affecting celery are celery mosaic and aster yellows. Celery leaf miner, carrot weevil and aphids are some of the insects which attack celery.

Celery is a biennial crop and the seed is produced in the hills.

PARSLEY

(Petroselinum hortense L.*)*

Parsley is grown as a garden herb. Its leaves are used to decorate or garnish meat platters and other dishes and in sandwiches. It is minced and strewn over potatoes, carrots or other boiled vegetables. It is also used in soups, sauces and stews. It is very rich in vitamin C. It is not commonly grown in India. There are two groups of varieties, one with plain leaves and the other with curled leaves or commonly known as **Moss-curled**. The variety, **Hamburg** has tough stem, deeply cut plain leaves and **Moss-curled** is dwarf with finely cut serrated and deeply curled leaves.

The seed of parsley is very small and germinates slowly. It can be directly sown in the field or sown in a nursery bed during September-October. Seedlings are planted 40 to 50 cm apart in rows with 12 to 15 cm between plants. The outer and larger leaves are harvested first. The plants continue to give leaf cuttings for several months.

Other salad crops, endive (*Cichorium edivia* L.), chicory (*Cichorium intybus* L.), chervil (*Anthriscum cerefolium*), cress (*Lipidium sativum* L.) and water cress (*Nasturtium officinale*) are not so important and are yet to be made popular in India.

CHAPTER XV

Leafy Vegetables, Potherbs or Greens

LEAFY VEGETABLES are very rich in minerals and vitamins A and C. They also supply the roughage required in the daily diet. The dieticians recommend daily consumption of at least 116 g of leafy vegetables for a balanced diet. A variety of greens is cultivated in India. The leaves of certain plants which grow wild are also used as vegetable. Some of the vegetables like cabbage, Chinese cabbage and kale considered in other groups may also be considered as green leafy vegetables. The leaves of some shrubs and trees are used as potherbs or greens. The leafy vegetables are grown throughout the year. Some are suitable for growing during winter months such as *palak*, spinach, fenugreek, mustard. Others like amaranth, *kulfa*, *poi*, are suitable for growing during summer.

BEET LEAF

(Beta vulgaris L.*)*

Hindi : *Palak*

This is the most common leafy vegetable grown in India. It is also known as Indian spinach. It is mainly grown for its tender succulent leaves but the tender seed stalk is also cooked in some parts of the country. The spinach grown in foreign countries is different from *palak*. It is of high nutritive value and the nutritive analysis is given below:

Moisture	86.4	g	Minerals	2.2	g
Protein	3.4	g	Other carbohydrates	6.5	g
Fat	0.8	g	Calcium	380	mg
Fibre	0.7	g	Iron	16.2	mg
Calories	46		Thiamine	0.26	mg
Phosphorus	30	mg	Nicotinic acid	3.3	mg
Vitamin A	9,770	I.U.	Vitamin C	70	mg
Riboflavin	0.56	mg			

History and Taxonomy

Palak is closely related to beet root, sugar beet and swiss chard. This particular beet leaf might have been first used in Bengal and that is why it is known as var. *bengalensis*. It belongs to the family Chenopodiaceae, genus *Beta* and species *vulgaris*.

Varieties

A number of varieties are grown throughout India. A good variety is characterised by its high quality of tender leaves, good and quick rejuvenation after each cutting and late appearance of seed stalk. The I.A.R.I. recommended variety is **All Green.** A new variety of *palak*, **Pusa Jyoti** with giant size leaves, high yield and nutritive value has also been evolved at the Institute.

Climatic Requirements

Palak has a much wider range of adaptability to climatic conditions. In places where extreme temperatures are not prevalent, it can be grown nearly throughout the year. It, however, performs best during winter months. When sown during summer months, the seed stalks develop early and only one leaf cutting is available.

Soil and Manurial Requirements

Palak is grown on all types of soils but clay loam suits it best. It is tolerant to slightly alkaline soil. *Palak* is sown several times in the year. It is sown once in early spring, again at the beginning of rains and for the main crop in September to November. In the hills, it is sown from March to May. About 30 kg of seed is required to sow one hectare. Generally seed is sown broadcast in a thoroughly prepared soil. It is, however, advisable to sow the seed in rows about 15 to 20 cm apart. This provides facilities for easier weeding in the earlier stages of growth.

For leafy growth nitrogen fertilizers are the first requirement. A basal dressing of 35 to 40 tonnes of farmyard manure should be incorporated in the soil at the time of preparation of the land. A top-dressing of about 20 kg of nitrogen after every cutting gives quick regrowth of green, tender succulent leaves.

Harvesting

The leaves are picked or cut from the base when they are 15 to 30 cm long. The main consideration is the tenderness and succulence of the leaves. During the summer months three to four cuttings are taken. The average yield during the best season is about 8,000 to 10,000 kg of green leaves per hectare. The variety with giant-size leaves may give about 30 to 40 per cent higher yield. The leaves should be sent to the market immediately after harvest.

Seed Production

Palak produces seed in the plains of India. It is a cross-pollinated crop with sessile, hermaphrodite flowers. The pollen grains are very small as in the case of other members of Chenopodiaceae and they are blown about by wind. Care should be taken to keep the field free from *bathua* (pigweed) and plants producing early seed stalks should be rogued out. Isolation distance of at least one kilometre is kept between varieties to produce pure seed. The seed yield is about 1,500 kg per hectare.

Diseases and their Control

A number of diseases caused by different fungi attack the leafy vegetables. The important ones among them are damping-off, cercospora leaf spot, mildew and rust. Damping-off attacks the young seedlings immediately after emergence and can be controlled by treating the seeds with Cerasan before sowing. The cercospora leaf spot which produces brown, dead spots on the leaves can be controlled by spraying any copper fungicide like Bordeaux mixture or Fytolan. Mildew and rust are not so common and can be partially checked by dusting sulphur and some copper fungicide.

Insect Pests and their Control

Insects are not so troublesome in growing spinach. The common insects are the aphids, some caterpillars and some beetles. These insects can be controlled by spraying any insecticide like malathion, but as leaves are continuously cut and used, poisonous insecticides should be avoided. Spraying with nicotine sulphate or dusting with 0.2 to 0.3 per cent pyrethrum should be preferred. Crops which are kept for seed are usually attacked by aphids during January-February. This, however, can be controlled by spraying malathion or Rogor.

SWISS CHARD

(Beta vulgaris var. *cicla)*

This is closely related to *palak*. The leaves are much bigger and the leaf stalk and veins are white. It is not commonly grown in India. It needs cool climatic conditions for proper development. The seed is produced only in the hills.

SPINACH

(Spinacia oleracea L.)

Hindi : *Vilayati palak*

This is the most important potherb or leafy vegetable grown in the U.S.A., Canada and Europe. This is, however, not yet popular in India and is grown on a limited scale in the hills and parts of north as well as south India. The shape of the leaves is quite different from that of *palak*. The nutritive value of spinach is as follows:

(per 100 g of edible portion)

Moisture	92.1	g	Protein	2.0	g
Fat	0.7	g	Minerals	1.7	g
Fibre	0.6	g	Other carbohydrates	2.9	g
Calories	26		Calcium	73	mg
Magnesium	84	mg	Oxalic acid	658	mg
Phosphorus	21	mg	Iron	10.9	mg
Sodium	58.5	mg	Potassium	206	mg
Copper	0.01	mg	Sulphur	30	mg
Chlorine	54	mg	Vitamin A	9,300	I.U.
Thiamine	0.03	mg	Riboflavin	0.07	mg
Nicotinic acid	0.5	mg	Vitamin C	28	mg

History and Taxonomy

Spinach was first cultivated by the Arabs and must have originated in South-West Asia. The Moors took it to Spain from where it spread to other parts of the world. The word spinach actually comes from a Spanish word *Hispania*. It belongs to the family Chenopodiaceae, genus *Spinacia* and species *oleracea*. The edible part consists of the compact rosette of leaves prior to the elongation of the central bud in flower stalk formation. There are four types of plants. The extreme males produce seed stalks sooner than do the vegetative males, females and hermaphrodite or monoecious plants.

Varieties

The original seed of spinach is prickly. The smooth or round seeded varieties were obtained as a result of mutation. The varieties can broadly be divided into savoy-leaved and smooth-leaved types and **Virginia Savoy** among the savoy-leaf type and **Early Smooth Leaf** in the other type are recommended by I.A.R.I. The former has prickly seed and blistered large dark green leaves and the latter has smooth roundseed, smaller light green smooth leaves with a pointed apex.

Climatic and Soil Requirements

Spinach is mainly a cool season crop. Low temperatures, specially at night, cause intense savoying in Virginia Savoy. High temperature decreases the savoying. The soil requirements are the same as those for *palak*. The optimum soil pH is between 6.0 and 7.0 for its maximum growth.

The cultural operations are the same as those for *palak*.

Seed Production

The seed of Virginia Savoy is produced on the hills, whereas those of the smooth-leaved varieties are produced in the plains. It is also a cross-pollinated crop and the pollen grains are carried by wind. The seedstalks first emerge in the extreme males which are followed by the vegetative males. These have some leaves on the flower stalks besides the male flowers. Plants of both these types do not bear any seed. The seed stalks of the hermaphrodite and the female plants appear later. Taking advantage of the separate male and female plants and knowing that some of the varieties combine well for certain characters, commercial production of F_1 hybrid seed has been taken up. The F_1 hybrids give higher yields of good quality greens. An isolation distance of 1.5 km should be kept for the commercial variety and 2.5 to 3 km for stock seeds. The seed yield per hectare may vary from 750 to 1,000 kg. The diseases and insect pests are about the same as those of *palak*.

FENUGREEK

(*Trigonella foenum-graecum* L.)
Hindi : *Methi*

The fenugreek is mainly grown in north India. The leaves and young pods are used as vegetables and the seed as condiments. It has also some medicinal value. It prevents constipation, removes indigestion, stimulates the spleen and the liver, and is appetizing and diuretic. The leaves are quite rich in protein, minerals and vitamin C and contain:

(per 100 g of edible portion)

Moisture	86.1 g	Minerals	1.5 g
Protein	4.4 g	Other carbohydrates	6.0 g
Fat	0.9 g	Calcium	360 mg
Fibre	1.1 g	Oxalic acid	13 mg
Calories	49	Iron	17.2 mg
Magnesium	67 mg	Potassium	31 mg
Phosphorus	51 mg	Sulphur	167 mg
Sodium	76.1 mg	Vitamin A	6,450 I.U.
Copper	0.26 mg	Riboflavin	0.15 mg
Chlorine	165 mg	Nicotinic acid	0.7 mg
Thiamine	0.05 mg	Vitamin C	54 mg

History and Taxonomy

Fenugreek is considered to be a native of Eastern Europe and Ethiopia and is also found growing wild in north-western India. It belongs to the family Leguminosae, genus *Trigonella* and species *foenum-graecum*. The *kasuri* or *chama methi* belongs to the same genus but species *corniculata*. These two differ in their growth habits. The common *methi* is quick growing and produces upright shoots and the *kasuri methi* is slow growing initially, and remains in a rosette condition during most of its vegetative growth period. The common *methi* produces two to three white flowers at the base of each leaf and has 6 to 7 cm straight long pods. The *kasuri* produces bright orange-yellow flowers on long stalks. It has smaller sickle-shaped pods.

Varieties

The I.A.R.I. has recommended one variety in each group. They are **Pusa Early Bunching** and **Kasuri.** The Maharashtra Agricultural Department has released an improved variety known as **Methi No. 47.**

Climatic and Soil Requirements

It is a cool season crop, and is fairly tolerant to frost. *Kasuri methi* needs a comparatively cooler climate. The soil and manurial requirements are about the same as those for other winter leafy vegetables like *palak* and spinach.

Sowing and Seed rate

Both types of *methi* are sown from the middle of September onwards. Common *methi* can be grown till early spring. The seed is generally broadcast in beds and surface raked to cover it. Sowing in rows of 20 to 25 cm facilitates weeding and intercultural operations in the initial stages. The common *methi* may take 5 to 6 days to germinate and *kasuri* 7 to 8 days. About 25 kg of seed of common *methi* and 20 kg of *kasuri* are required for one hectare.

After care

Some weeds come up in the initial stages but once the field is covered by the crop, the weeds are suppressed. Frequent irrigation is necessary for obtaining quick growth of the crop. Ample moisture in the soil keeps plants succulent and gives more number of cuttings.

Harvesting and Yield

The *kasuri methi* gives a number of cuttings. The first cutting is made in about 25 to 30 days after sowing. The leaves, if allowed to over-mature, may taste bitter. In the case of common *methi*, the young shoots are nipped off in about three weeks after sowing. Later on, the whole plant is often pulled out, bunched and marketed. Sometimes after taking 2 to 3 cuttings, the plants are left to produce seed.

The yield varies with the method of harvest in both types. The common *methi* may give a yield of 7,000 to 8,000 kg per hectare, whereas the *kasuri* type gives a higher yield of about 9,000 to 10,000 kg.

Seed Production

Both types seed freely in the plains of India. Often the crop is left for seeding after taking 2 to 3 cuttings. This method reduces the yield of seed. The crop left entirely for seed gives a much higher yield. Pusa Early Bunching may yield 1,200 to 1,500 kg and Kasuri 600 to 700 kg of seed per hectare if no leaf cutting is taken.

MUSTARD

(Brassica spp.)
Hindi : *Sarson*

The mustard leaves and tender stems form the most popular winter greens in the rural areas of the Punjab, Delhi and western Uttar Pradesh. This is rich in protein, minerals and vitamins A and C. The nutritive value may differ from species to species. However, a general nutritive analysis is given below:

(per 100 g of edible portion)

Moisture	89.8	g	Minerals	1.6	g
Protein	4.0	g	Other carbohydrates	3.2	g
Fat	0.6	g	Calcium	155	mg
Fibre	0.8	g	Iron	16.3	mg
Calories	33		Thiamine	0.03	mg
Phosphorus	26	mg	Vitamin C	33	mg
Vitamin A	4,370	I.U.			

Taxonomy and Varieties

A number of different species are grown in different parts of the country. Some are grown exclusively for oilseed, some exclusively for leafy vegetable and some are grown for dual purpose. The brown *sarson* (*Brassica campestris* L. var. *dichotoma* Watt.) is grown in the Punjab, whereas yellow *sarson* (*B. campestris* L. var. *sarson* Prain) is commonly grown in U.P., Bihar and Bengal. *B. campestris* L. var. *cuneifolia* Roxb. is grown in north Bengal and Assam. *B. campestris* L. var. *rugosa* and *B. napus* are also grown for their leaves and tender stems. Some of the leaves are dehydrated, packed and sold in the market. Some of the Japanese mustard plants have large leaves and are exclusively grown for vegetables.

Seed Sowing

Seed is sown alone or mixed with wheat. In the plains, it is sown from the middle of September to the end of November. In the hills, sowing is done during May to July. When sown for vegetable purposes, the seed is sown at about 33 cm apart in rows and 10 cm between the plants. For the large-leaved varieties, more spacing is given. The seed rate is about 6 to 7 kg per hectare. When broadcast, a higher seed rate is required. The seed takes five to six days to germinate.

Climatic and soil requirements are the same as those for other winter leafy vegetables.

Harvesting

When the crop is grown for dual purpose, that is, for green leaf and oilseed, the leaves are picked in about 25 to 30 days after sowing. Care should be taken to keep enough leaves on the plants for normal photosynthesis needed for the development of seed stalks. About 1,000 to 1,200 kg of seed can be obtained from one hectare.

Insect Pests

The main problem in mustard is aphids which start attacking from January onwards. Some of the systemic insecticides like Disystox, Phorate or Thimate which are applied with irrigation water are quite easy and effective. If the crop is for seed purpose periodical sprays of malathion can control the aphids. When the crop is for vegetable purpose, less poisonous insecticides like pyrethrum extract or nicotine sulphate are sprayed to control the insect attack.

OTHER WINTER LEAFY VEGETABLES

A number of other vegetables which are grown on a limited scale during the winter season and used as greens are *karam sag*, New Zealand spinach, buck wheat, *bathua*, sorrel, *chakwat*, kale, radish leaves, tender gram, pea twigs and others. The leaves of these being highly nutritious are often cooked and eaten as greens.
Karam Sag (*Brassica oleracea* var. *acephala*): It is very popular in Kashmir and is also grown to some extent in Assam. The young

shoots and leaves are used as greens. It is closely related to the cabbage family.

New Zealand Spinach (*Tetragonia expansa*): It belongs to the family Aizoaceae. The leaves resemble spinach but are smaller. The plants are much branched and spreading. It thrives during the hot weather and replaces spinach when the latter is not available.

Buck Wheat (*Fagopyron tataricum*): It is very commonly grown in the hills of Himachal Pradesh. The tender tops are picked periodically for use as greens. In the hills it is sown with the break of the monsoon.

Bathua (Pigweed): It is one of the most common winter weeds. Its leaves are sometimes used as greens.

Sorrel (Rumex vesicarius L.*)*: Commonly known as *khatta palak*, it is grown for its sour leaves. When the plants flower, they look very attractive and are often used as an ornamental plant.

Chakwat (Atripex hortensis): Commonly known as orach or mountain spinach, it has a somewhat strong flavour than spinach. The leaves become suitable for harvest 4 to 5 weeks after sowing. In the later stages, the tender leaves can be picked from the branches of the mature plants. It is grown on a smaller scale in Maharashtra and Karnataka during the winter season and in Kashmir during the summer.

CHAPTER XVI

Summer Leafy Vegetables

AMARANTH

(Amaranthus spp.*)*
Hindi : *Chaulai*

THERE ARE a number of different types of amaranth. All are grown during the summer and the rainy season. This is the most common leafy vegetable grown during the summer in India. The leaves and tender stems are rich in protein, minerals and vitamins A and C. The general nutritive analysis is as follows:

(per 100 g of edible portion)

Moisture	85.7	g	Protein	4.0	g
Fat	0.5	g	Minerals	2.7	g
Fibre	1.0	g	Other carbohydrates	6.3	g
Calories	46		Calcium	397	mg
Magnesium	247	mg	Oxalic acid	772	mg
Phosphorus	83	mg	Iron	25.5	mg
Sodium	230	mg	Potassium	341	mg
Copper	0.33	mg	Sulphur	61	mg
Chlorine	88	mg	Vitamin A	9,200	I.U.
Thiamine	0.03	mg	Riboflavin	0.10	mg
Nicotinic acid	1.0	mg	Vitamin C	99	mg

Amaranth belongs to the family Amaranthaceae and to the genus *Amaranthus*. There are about six different species in cultivation. The most common are *A. blitum* and *A. tricolor* which are known as *chhoti* and *badi chaulai*, respectively. *A. caudatus* is grown for seed and the other species grown on a limited scale in Orissa and south India for green leaves are *A. Mangostanus, A. lividus* and *A. dubius*.

All amaranths are suitable for growing in the summer as well as the rainy season. *Chhoti chaulai* is suitable for sowing in spring and it gives green leaves throughout the summer. The plants are dwarfish with small leaves and rejuvenate quickly after each cutting. There are two varieties, one green and the other red. The plants of *Badi chaulai* are taller with thicker stems and larger leaves. This type can be grown in the summer as well in the rainy season. The green variety is more common but the red one is also available. In Tamil Nadu both **co. 1** and **co. 2** are popular.

The seeds are very small, so they are sown very shallow. The seed is sown broadcast in rows or in flat beds after mixing them with fine earth for uniform distribution. About two to two-and-a-half kilograms are required for sowing one hectare. When sown in rows, the spacing is kept at 20 to 25 cm for *Chhoti chaulai* and 30 to 35 cm for *Badi chaulai.* The latter is sometimes transplanted after raising the seedlings in the nursery during the rainy season. The spacing during this season is kept at about 45 cm from row to row and 30 cm from plant to plant.

Harvesting usually starts about three to four weeks after sowing. *Chhoti chaulai* gives about six cuttings and the *Badi* gives about two to three more.

It is a cross-pollinated crop and sufficient isolation distance should be kept between varieties. The seed yield per hectare is about 200 kg.

PORTULACA

(Portulaca oleracea L.*)*

Hindi : *Kulfa*

Portulaca grows wild in summer. It is also cultivated to some extent. The improved types have broad leaves. The shoots grow erect when sown thickly. It is sown in early spring. The succulent branches are cut when they grow 15 to 20 cm in length. The crop becomes ready for the first cutting in about a month after sowing. The sowing and other cultural operations are the same as those for amaranth. It belongs to the family Portulacaceae. The fruit is a capsule and the seeds are collected after breaking them open.

MALABAR NIGHTSHADE or INDIAN SPINACH

(Basella alba L.*)*

Hindi : *Poi*

Poi is a common leafy vegetable grown in north-east and south India. The plant has fleshy stems and leaves and is of a trailing habit. It is propagated through seeds or by stem-cuttings. It belongs to the family Basellaceae and has a red variety also which belongs to the species *rubra*. It is either staked on bamboo *machans* or trained on trellis.

Other summer leafy vegetables which are used in some parts of the country are colocasia leaves (*Colocasia esculenta*), jute (*Corchorus olitorius*), young bottle gourd twigs (*Lagenaria siceraria*), young pumpkin twigs (*Cucurbita moschata*) and others.

TWIGS AND LEAVES OF TREES AND SHRUBS USED AS LEAFY VEGETABLES

There are a number of perennial trees and shrubs the leaves or tender twigs of which are often used as leafy vegetables. Some of these leaves are very rich in nutritive value. They are *chakur manis* (*Saropus androgynus*), *agathi* (*Sesbania grandiflora*), tamarind (*Tamarindus indica*), curry leaf (*Murraya koenigii*), and drumstick (*Moringa oleifera*) of which flowers and fruits are mostly eaten.

CHAPTER XVII

Other Root Crops

COLOCASIA

(*Colocasia esculenta* Schott.)
Hindi : *Ghuiyan* or *Arvi*

COLOCASIA IS used as food and is prepared in many ways. The tubers are boiled and served about the same way as the potato. The tubers make good chips. The young leaves and petioles are used as food in some areas. They are cooked like other green vegetables. The tubers of some variety have acridity, which is due to needle-like crystals of calcium oxalate. Most of the cultivated varieties are free from acridity. However, it is best not to taste any variety raw. The acridity is destroyed by cooking. The nutritive value of colocasia is as under:

(per 100 g of edible portion)

Moisture	73.1	g	Protein	3.0	g
Fat	0.1	g	Minerals	1.7	g
Fibre	1.0	g	Other carbohydrates	21.1	g
Calories	97		Calcium	40	mg
Phosphorus	140	mg	Iron	1.7	mg
Sodium	9.0	mg	Potassium	550	mg
Vitamin A	40	I.U.	Thiamine	0.09	mg
Riboflavin	0.03	mg	Nicotinic acid	0.4	mg
			Vitamin C		Nil

The *arvi* originated in the tropics of the old world. It belongs to the family Araceae, genus *Colocasia* and species *esculenta*. The leaf blades are very large and the petioles long. The underground parts consist of one or more large edible central corms and a large number of cormels, commonly known as tubers.

It is a warm season crop and is grown as a summer as well as a rainy season crop. The summer crop is sown in February-March and the rainy season crop in June-July. Sprouted tubers are sown in rows about 45 cm apart and 30 cm within the row. They should be sown in the presence of ample moisture in the soil. In case the germination is not complete, one light irrigation helps the process. One or two light earthing up operations are done. If there are a large number of shoots coming out, shoot pruning is practised, leaving one or two main shoots. The crop can be harvested from about three months after sowing. The crop however, matures in about 130 to 140 days and if harvested at that time gives a yield of 15,000 kg per hectare.

There are no serious insect pests and diseases attacking this crop. Colocasia blight may become a serious disease in some years in some localised areas. The first symptoms are seen on the leaves and then on the petioles. The corm is attacked and rots in severe cases. To prevent the disease, healthy corms should be used as seeds. Spraying Bordeaux mixture also controls the disease. Once the disease appears in one plot, it is advisable not to grow colocasia in that plot for the next two seasons.

YAMS

(Dioscorea alata L.*)*

Hindi : *Ratalu*

Yams constitute an important source of food in the tropical areas of America and Asia. They are a rich source of carbohydrates. They belong to the family Dioscoreaceae and genus *Dioscorea,* which contains about 250 species of climbing vines with large storage roots. All species, however, do not produce edible roots. Among the species cultivated are *D. alata* or greater yam, which produces large tubers, each even weighing 25 to 30 kg. The small to medium-sized are preferred as food. The other species are *D. caryenensis*, yellow yam; *D. batatas*, Chinese yam; *D. trifida*, yampee; *D. bulbifera*, air potato grown sometimes for its aerial tubers and *D. esculenta (Suthni)*, commonly grown in eastern U.P. and Bihar. The last species is cultivated to some extent in north-eastern India. *D. alata* is more commonly grown in the tropical and sub-tropical regions of the country. Some species of *Dioscorea* have medicinal properties. Their extracts are used for treatment of arthritis.

Varieties differ in size and colour of roots. Some are white-fleshed, others yellow. Some purple-fleshed varieties are popular in south India.

A deep, rich, friable, well-drained soil is ideal for growing yam. The method of sowing is the same as that for colocasia, except that in the case of varieties having larger roots, a wider spacing is given. Sometimes the vines are staked on bamboo supports or on trellis. On well-drained soil no staking is needed. The harvesting and curing is done as in the case of colocasia. The roots are very tender and brittle and so sufficient care is to be taken at the time of handling. The best storage temperature is 14°C to 15°C.

TAPIOCA

(Manihot esculenta)
Hindi : *Tikhoor*

Tapioca, which is also known as manioc, yuca or cassava, is a very important food crop in South America and also in other tropical parts of the world. The plant is herbaceous and is cultivated for its tuberous roots 3 to 5 cm in diameter and one metre or more in length. In tropical areas, this is often used as a supplementary food, being high in carbohydrate content. Tapioca roots are eaten either after boiling or baking. Flour or meal made from the roots is used in making bread and other dishes. Starch is also manufactured for paper, laundry and other industrial products. The nutritive analysis is as below:

(per 100 g of edible portion)

Moisture	59.4	g	Minerals	1.0	g
Protein	0.7	g	Other carbohydrates	38.7	g
Fat	0.2	g	Calcium	50	mg
Fibre	0.6	g	Iron	0.9	mg
Calories	159	mg	Thiamine	0.05	mg
Phosphorus	40	mg	Nicotinic acid	0.3	mg
Riboflavin	0.10	g	Vitamin C	25	mg

Tapioca belongs to the family Euphorbiaceae, genus *Manihot* and species *esculenta*. There are two types known as "bitter" and "sweet". The bitter type produces higher yield and is more commonly grown. The colour of the tuber varies from white to reddish white or brown. Most varieties contain a poisonous glucoside, which is eliminated after boiling. There are many varieties grown in south India.

Tapioca cannot withstand frost and prefers well-drained sandy loam soils. The manurial practices followed for other tuber crops may also be followed for tapioca. The duration of the crop being longer, it may need an extra top-dressing of a nitrogenous fertilizer.

Tapioca is propagated by cuttings. Cuttings about 15 to 20 cm long are taken from mature plants. The cuttings are planted in shallow trenches at a spacing of one metre each way. The tubers become ready for harvest in 8 to 12 months, depending on the variety. For home use and sale in local markets, the crop can be harvested in about 6 months after planting as needed. Most of the tubers contain 80 to 85 per cent starch and this may deteriorate and the tubers may become fibrous if not harvested once they reach full maturity. The plants are cut back before digging out the roots. The yield per hectare varies from 25,000 to 35,000 kg of tubers. The tubers can be stored for several weeks in a warm dry place.

ELEPHANT'S FOOT

(*Amorphophallus campanulatus* Blume)
Hindi : *Suran, Zamikand*

The elephant's foot or yam originated in India and is grown for its tubers which can be stored for long periods. The nutritive analysis of this crop is as follows:

(per 100 g of edible portion)

Moisture	78.7 g	Protein	1.2 g
Fat	0.1 g	Minerals	0.8 g
Fibre	0.8 g	Other carbohydrates	18.4 g
Calories	79	Calcium	50 mg
Phosphorus	34 mg	Iron	0.6 mg
Vitamin A	434 I.U.	Thiamine	0.06 mg
Riboflavin	0.07 mg	Nicotinic acid	0.7 mg
		Vitamin C	Nil

This yam belongs to the family Araceae, the genus *Amorphophallus* and species *campanulatus*.

There are two distinct types of yam. One has smooth corms and is propagated by small pieces of corms. This type has acridity and causes irritation to the mouth and throat but gives a higher yield. The acridity can be diluted by boiling. The other type is propagated by cormels or daughter corms and is superior in quality and free from acridity. The flesh colour ranges from white to light pink. It does best in rich, sandy loam soils. The best time to sow is early spring. A corm used as seed may be weighing only a few grammes. It takes three to four years for this corm to become a few kilograms in weight. In parts of Gujarat, elephant's foot is grown in flat beds, whereas in certain parts of the southern States, it is grown on broad ridges. It is mainly a tropical and sub-tropical crop. It requires a well distributed rainfall or irrigation, and the range of maximum and minimum temperatures should not be wide. This yam is often grown mixed with ginger and banana. Some crops like *guar*, groundnut and *methi* are sometimes used as a cover crop in the fields of elephant's foot.

Harvesting is done by digging the corms individually by a spade. The buds on the fourth year corms are removed and preserved for planting as a first year crop. The yield per hectare is about 30,000 to 40,000 kg of tubers in the mature state.

CHAPTER XVIII

Perennial Vegetables

PERENNIAL VEGETABLES are those which produce the edible portion continuously for several years. They occupy the land for a number of years and therefore should be located where they will not interfere with normal tillage operations for other crops. When grown in the home garden, they should be planted in one side of the main plots for growing annuals. The vegetables which are grouped as perennials are asparagus, rhubarb, artichoke and sea kale. These crops have tuberous roots, rhizomes or crowns. The upper portion may dry up during very cold winter months and again sprout with the coming of spring. A number of cucurbits like cho-cho (*Sechium edule*) can also be considered as perennial vegetables. There are some fruit crops too which are commonly cooked as vegetables in the immature stages. They are plantain, papaya and jack fruit. The drumstick is also another popular perennial vegetable.

ASPARAGUS

(*Asparagus officinalis* L.)

Hindi : *Shatawar*

The asparagus is cultivated for its tender shoots, commonly known as spears. The spears are treated as a delicacy in preparation of soup and other vegetable products. Large quantities of asparagus spears are canned and frozen. It starts yielding a sizable crop after about three years and with good care gives an economic yield for about 10-15 years. The yield goes on increasing for 6-7 years, then remains uniform up to about 12 years, after which it gradually declines. The best quality is obtained from the fourth to the tenth year. The edible portion contains:

Moisture	93.0	per cent	Ash	0.6	per cent
Fat	0.2	"	Total carbohydrates	3.9	"
Calcium	0.21	"	Sugar	1.3	"
Fibre	0.7	"	Iron	0.0012	"
Starch	0.4	"	Calories per 450 g	120	
Protein	2.2	"			

History and Taxonomy

Asparagus is a native of the eastern Mediterranean lands and Asia Minor. It has been in cultivation for over 2,000 years. The Greeks and Romans prized it for its medicinal value. It has not yet become popular in India but the demand is gradually increasing.

Asparagus is the only popular vegetable representing the family Liliaceae, which has more than 150 different species. The ornamental asparagus or 'smilax' is also closely related to it. The garden asparagus belongs to *Asparagus officinalis* Linn. var. *altilis* Linn.

The varieties are broadly divided into two groups, one with spears overcast with purple and the other with spear tips almost free from the purple overcast. The recommended variety of the I.A.R.I. is **Perfection.**

Soil and Soil Preparation

Asparagus grows well on any kind of soil but a deep sandy or sandy loam soil is preferred. The optimum pH requirement for asparagus is between 6.0 and 6.7.

Proper preparation of soil is essential as the crop occupies the soil for a number of years. A good amount of organic manure should be incorporated at the time of preparation of the soil. A yield of 17.5 quintals of asparagus removes 44 kg of nitrogen, 12.5 kg of phosphate and 40 kg of potash. It is, therefore, necessary to add about 50 to 60 kg of nitrogen, 25 kg of phosphate and 50 kg of potash every year. The best way of applying fertilizers is to apply them in two doses. The first dose may be given in early spring before the start of growth and then again after the harvest is complete. Application of common salt is often beneficial in the cultivation of asparagus.

Raising Plants of Asparagus

The seeds are sown in a well prepared nursery bed in rows half a metre apart. The seedlings are allowed to grow for one year in the nursery bed and are then planted at the permanent site. The seed is sown in early spring and takes 3 to 4 weeks to germinate.

Asparagus plants are dioecious in character that is, the male and female plants are separate. The male plants bear more spears than the female plants. It is not possible to recognise the sex of the plants in the nursery as most of the plants will not flower in a year. The age of transplant is one year seedling or crown. Therefore selection is usually made on the basis of root growth. Those crowns which have a good growth and branching should be selected. Older crowns may have more roots but a number of them may already be mutilated. The crowns are dug up from the nursery at depths of about 20 cm. The rows are spaced at about 1.5 to 2 metres and 45 to 60 cm distance is kept within the rows.

When the rows are far apart, the interspace can be utilised for the first 2 to 3 years by growing some intercrops. Every year it is desirable to disk and harrow thoroughly and apply fertilizers before the growth starts. Sometimes blanched (whitish) spears are preferred particularly for canning. The green spears being higher in nutritive value are preferred now for the fresh market or for processing. Harvesting is done from the third year onwards. In the second year some spears may be available. It is harvested every day during spring. Spears may be cut by a special knife which cuts 3 to 5 cm below the soil surface. Asparagus loses quality quickly after harvest. So it should be sent to the market as soon as possible. The average yield per hectare every year is about 3,500 to 4,000 kg.

Asparagus rust is the most serious disease. The tops of the plants are destroyed when severely attacked. There are some varieties which are resistant to rust. In places where the disease is prevalent, it is advisable to grow such varieties.

The other disease which is not so common as rust is *Fusarium* wilt. Spears affected with wilt may show a brown discoloration and become wilted and stunted. There is no direct control measure as the disease organism is soil-borne. It is best to avoid the neighbourhood of such soils as show wilt for planting asparagus.

Asparagus beetles and garden centipedes are the only insect pests which attack asparagus.

ARTICHOKE OR GLOBE ARTICHOKE

(Cynara scolymus L.*)*
Hindi : *Hathichak*

The artichoke, commonly known as globe artichoke, is a perennial crop grown for its flower bud. The edible portion contains:

(per 100 g of edible portion)

Moisture	77.3	g	Protein	3.6	g
Fat	0.1	g	Minerals	1.8	g
Fibre	1.2	g	Other carbohydrates	16.0	g
Calories	79		Calcium	120	mg
Phosphorus	100	mg	Iron	2.3	mg
Vitamin A	63	I.U.	Thiamine	0.23	mg
Riboflavin	0.01	mg	Vitamin C		Nil

The globe artichoke has originated from the Mediterranean region of Southern Europe and Northern Africa. It belongs to the family Compositae and has thistle-like plants. Its scientific name is *Cynara scolymus.* The above-ground portion dies each year during winter and again emerges in spring. It is generally propagated by means of suckers or off shoots from the old root-stocks and also by dividing the old crown into pieces with a portion of the stem. The buds are harvested before they become loose and fibrous. The stem is cut 2.5 to 3 cm below the base of the bud.

JERUSALEM ARTICHOKE

(Helianthus tuberosus)

The jerusalem artichoke belongs to the same family but to a different genus. Its scientific name is *Helianthus tuberosus.* It is cultivated for its oblong tubers. It is a native of North America. The cultivation of this crop has not expanded. It is recommended as feed for hogs and also used as a human food. The carbohydrate insulin is stored in the tubers. This is of interest because of its value in the diet of persons suffering from diabetes. It has wide adaptability to a range of soil and climatic conditions. It is not yet popular in India.

SEA KALE

(Crambe maritima)

It is a hardy perennial of the family Cruciferae. It is grown for its young leaves and shoots. This is also not commonly grown in India.

HORSE RADISH

(Armoracia rusticana)

The horse radish is a perennial crop grown for its pungent roots. These are mixed with salt and vinegar, and eaten as a relish, condiment, or appetizer with meat and other foods. The pungency is due to the presence of an allyl isothiocyanate and butylthiocynate similar to the mustard oils, occurring in combination with the glucoside sinigrin. The crop is propagated by root cuttings. The sets are usually made from side roots which are trimmed off in preparing roots for the market. It is also propagated by crowns, a portion of the old plant consisting of a piece of root and crown buds.

RHUBARB

(Rheum rhaponticum L.)

Rhubarb is not commonly grown in India. It is grown for its large, thick leaf stalks which are used for sauces and pies. The nutritive analysis of rhubarb is as follows:

(per 100 g of edible portion)

Moisture	92.7 g	Calories	24
Protein	1.1 g	Calcium	120 mg
Fat	0.5 g	Phosphorus	10 mg
Minerals	1.1 g	Iron	2.2 mg
Fibre	0.3 g	Vitamin C	37 mg
Other carbohydrates	3.7 g		

It is sufficiently rich in vitamin C and contains traces of vitamins A and B_2. Rhubarb originated from the colder parts of Asia, probably Siberia. It belongs to the family Polygonaceae, genus *Rheum* and species *rhaponticum*.

Rhubarb grows best in cooler climatic conditions and is resistant to cold and dry conditions. The plants are tolerant to soil acidity and grow well on soils that are slightly to moderately acid. It is one of the heaviest garden feeders and responds to extra-heavy application of well rotted manure and fertilizers. A yield of 70 tonnes per hectare removes 280 kg of nitrogen, 180 kg of phosphate and 500 kg of potash.

Rhubarb is propagated by divisions of crown. Each bud is divided into small pieces with one bud in each piece. The spacing is usually kept at half to one metre within rows and one to one-and-a-half metres between rows.

Harvesting is deferred till the third year. The stalks are pulled out, not cut. Immediately after pulling, the leaf blades are severed, leaving 3 to 4 cm of midribs with intervening tissues. Pulled stalks are kept in a cool shady place. Some leaves with stalks are always kept and the plant is never stripped of all its leaves. New stalks come up and become ready for harvest in about 7-10 days. The commercial age of planting is about 5-7 years. Rhubarb stalks can be stored for 2-3 weeks of 0°C and 90-95 per cent relative humidity.

Crown rot and leafy spot are some of the diseases which attack rhubarb. Following sanitary cultivation, dipping the roots into corrosive sublimate (1 : 1,000) or formaldehyde (1 : 240) are the control measures. The leaf spot can also be controlled by spraying Bordeaux mixture in spring when growth starts. The rhubarb beetle is the only insect attacking the crop. It makes holes on the leaves. The control is handpicking and destroying the insects as use of poisonous insecticide on rhubarb leaves is generally avoided.

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In the present book Dr. Choudhury has not only given scientific facts about vegetables but has also included valuable practical tips for the common man who wants to grow different kinds of vegetables under conditions existing in India.

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